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A foresight study of factors affecting the health system research and technology

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Abstract:

CONTEXT: The success of the health system research and technology management in the 21st century can play an important role in advancing the country toward becoming a scientific power.

AIMS: The study aimed to increase knowledge and identify factors affecting the health system research and technology, as well as to provide solutions for improving the status of health science and technology.

MATERIALS AND METHODS: This was an applied and descriptive study conducted in 2018 using cross-impact analysis. The factors affecting the Iranian Health System Research and Technology Management and their influences on each other were identified using an expert panel. The key-driven factors were determined using the MICMAC software.

RESULTS: The input, stake, target, resultant, excluded, and regulating factors were identified. The degree of fill rate the matrix was 58.9%. Financial annex of the health scientific map (S = 206), roadmap (S = 206), governmental laws and regulations (S = 198), and sufficient governmental budget allocation (S = 194) earned the highest potential influence scores by 2025. Furthermore, scientific authority (S = 216), international communication (187), university relationship with industries (S = 187), and competitive infrastructure (S = 178) obtained the highest potential dependence scores by 2025.

CONCLUSIONS: The success of the Iranian Health System Research and Technology Management by 2025 requires the development of the financial annex of the comprehensive scientific health map, the development of the road map, and the allocation of sufficient governmental budget for health research. Policy-making in health system research and technology management requires more attention to these factors and the dynamics of relationships among factors in the model.

Keywords:

Biomedical technology, health policy, Iran, national health programs, research and development

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Introduction

Foresight science has facilitated future studies through transforming studies on the field of planning for the future into science with solid principles and precise methods.[1] The process of foresight helps identify and introduce the driven forces, analyze their direct and indirect effects on each other, and finally, introduce the key-driven forces to plan for the future.[2]

Based on the country's development vision document, Iran should be a developed country with the first place in the fields of economy, science, and technology in the region with an Islamic and revolutionary identity, inspirational in the Muslim world and with a constructive and effective interaction in its international communication.[3] The first place of health in the region by the year 2025 is achieved by utilizing the existing knowledge and producing science and technology with the achievement of strategic goals, including

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gaining the first place in science, technology, and innovation in the field of health, achieving the scientific authority of the region with a global level in the postgraduate level, and the achievement of the leading position in the researches and studies conducted in the region.[4] The most important factor for success in the competition among countries is innovation. Innovation is due to the development of research and technology.[5] In line with the comprehensive scientific map of the country, which is a dynamic and prospective set of strategic and technological transformations for achieving the country's vision, a health scientific map (HSM) has been developed.[4,6]

Examining and ensuring the growth of health science and technology is one of the concerns of policymakers in the health system science and technology. Owlia and Ghanei studied the scientific development in all medical sciences trends. They stated that at the beginning of 2013, medical sciences had the largest share of the total scientific production in Iran (approximately 23.6%). According to this study, it was predicted that if the current growth trend continued, Iran would achieve the highest ranking in the Middle East in 2015.[7] It seems that the country has some restrictions on achieving international position. There are reports that express concerns about the country's scientific progress.[8-10] Efforts have also been made to provide a model for the evaluation of science and technology in the country,[11] as well as the opportunities for improving the country's scientific map have been presented through conducting critical reviews,[12] and it has been warned that adherence to the index can lead to adherence to the quantity.[13]

The most important challenges of Kerman University of Medical Sciences for reaching the objectives of the country's HSM have been identified, and corrective strategies have been provided. Ten basic categories of policy and management, financing and facilitation of academic processes, development and promotion of human resources of the university, development and promotion of education, conducting researches, knowledge dissemination, entrepreneurship, service delivery, culture and norms, and facilitating communication, as well as 46 subcategories of challenges have been identified.[14] In another qualitative study, the activities necessary for reaching the objectives of the HSM in the field of education have been identified in Iran, Shiraz University of Medical Sciences.[15] Although these studies have identified factors affecting the achievement of progress in the health science and technology, and some suggestions have been offered such as paying attention to the policy and management, culture and norms, and development and promotion of education,[14] considering the importance of roadmap,[13] paying attention to the science and technology chain,[12] the need to pay attention to the effective teaching,[15] and emphasizing science itself rather than scientific ranks and grades,[8] none of these studies have rated those factors and prioritized the proposed interventions. In order to determine the impact and position of each factor, the cross-impact analysis (CIA) can be used as a futuristic approach.[2]

CIA is a very useful tool for qualitative analyses of complex issues. This is a semi-quantitative method in which, instead of simple cause-effect relationships, the interactions among different subsystems are analyzed in a matrix. CIA, as a tool used in the future studies, reveals the impact of a variable on other variables within a system and identifies those variables that play an important and significant role in developing the system in the future.[5] The quality of variable distribution in the scatter diagram indicates the stability or instability of the system. In the stable systems, the distribution of variables has a pattern. In the unstable systems, the situation is more complicated, and variables are scattered around the diagonal line, and variables in most cases have an intermediate state of influence and dependence, which makes it difficult to assess and identify the key factors.[16]

On the other hand, several studies have used the interpretive structural modeling approach and CIA. This method has been used in the future studies of issues in Iran, and with the aim of trying to identify the trends, challenges and possible driven variables, has organized and summarized the views of citizens and experts, and then expressed them in order to increase the readiness for the possible, probable, and preferable futures for the Iranian Society.[17] Some of the applications of the CIA have been in identifying the key-driven factors of the creative village approach,[18] determining and analyzing the key factors affecting urban development using the prospective approach,[19] identifying and classifying the barriers affecting medical waste management,[20] analyzing the barriers to the development of medical equipment,[21] identifying and modeling the important factors for integrating sustainability with innovation for small- and medium-scale manufacturing companies,[22] developing a conceptual framework for strategic technology management,[23] and foresight the knowledge and information science education in Iran.[2]

The present study aimed to increase knowledge and identify factors affecting the health system research and technology management. Therefore, the aim of this study was to assess the interrelationship between identified factors affecting the Iranian Health System Research and Technology. The CIA was used as a foresight tool to categorize these factors and to provide solutions for improving the status of health science and technology and make suggestions for creating scenarios in the health sector.

Materials and Methods

The study was an applied and descriptive study conducted from September 2017 to March 2018 using CIA. The study population included all the experts of the health research and technology management domain located at the Ministry of Health and Medical Education or universities of medical sciences and top management of the medical sciences universities with more than 5 years of experience from among them seven people were selected using purposeful sampling method with maximum diversity. The CIA method is inherently a mixed method that identifies factors qualitatively, determines direct and indirect influence and dependence factors, and finally, identifies future key factors.[5] The data were used from a dissertation entitled "The dynamic model of research and technology management in Iran's health system" that was provided in two phases. The first phase, as a qualitative study, was conducted to identify factors affecting the research and technology of the health system.[24]

In the second phase, whose results have been presented in this article, the key factors were identified and categorized using CIA. The cross impacts of identified factors were analyzed using an expert panel including seven experts interviewed in the first phase. A researcher-made questionnaire based on the matrix of factors was used. The identified factors were examined in the form of binary questions about the impact of a factor on other factors. Then, they determined that how much factor A had influences on factor B. For each element of the matrix, 88 times this question was asked that whether the factor in row I affected the factor in column J or not. This influence was characterized by a numerical scale of 0–3, so that 0 = without impact, 1 = low impact, 2 = moderate impact, and 3 = great impact. In order to determine the potential or probable effect of the studied factors on the health system research and technology management until 2025, the letter "P" (potential influence) was used. Overall, five sessions were held including one 3-h session and four 2-h sessions. The reliability was measured by the matrix stability and degree of fill rate.

This phase consisted of five steps as follows:[5,16,17]

1. Providing a list of factors: Eighty-nine factors were identified as factors affecting the health system research and technology management
2. Preparing an n × n diagonal matrix based on the number of factors: In other words, an 89 × 89 matrix was formed. For this purpose, the identified themes and categories identified as the factors of the dynamic model of the health system research and technology management entered into the MICMAC software, version 6.1.2, 2003/2004: 3IE/EPITA, France. Due to the software constraints, the short name of factors was used
3. Judgment on how much factor A had impact on factor B: For each matrix element, 88 times this question was asked that if the factor in row I had influence on the factor in column J or not. The mode of the responses based on expert consensus was selected as a factor influence
4. Reviewing the results and performing the statistical analyses: The sum of each row shows the level of influence, indicating the extent to which the factor affects other factors. The sum of each column represents the level of dependence of each factor. The results of the CIA can be divided into three categories. First, based on the matrix of direct impact, the most important influence and dependence factors were identified. Second, based on the calculation of the first-order indirect influences of the factors on each other, the most important factors having indirect influence and dependence were identified. In this method, each of the relationships of the factors was increased to the power of 2, 3, 4, and 5 by the software and accordingly, the indirect influences of the factors were measured. Then, by adding the data on the probability influences, the direct and indirect influence and dependence were reidentified. Finally, on the basis of the calculations performed, the places and positions of the factors were plotted on the influence-dependence diagram using the MICMAC software
5. Categorizing factors: The results of the statistical analyses and drawing diagrams were presented in the following five categories: (A) inputs which affected the entire system. (B) Intermediate or relay factors which had two common characteristics of high dependence and high influence and any changes in them would change other factors. These factors could be divided into two categories of stake and target factors: (1) stake factors which had a large capacity to become key actors in the system and (2) target factors which had the evolutionary results of the system and represented the possible targets of a system. (C) Resultant or depending factors which had very high dependence and very low influence on the system. (D) Autonomous or excluded factors which had low dependence and influence. (E) Regulating factors which had been located near the center of the scatter diagram. They had the regulatory mode and sometimes acted as the secondary levers.[16,17]

The present study was conducted by obtaining informed consent from the participants, and they were ensured of the confidentiality of their names and opinions.

Results

The study was conducted to identifying the input, stake, target, resultant, excluded, and regulating

factors affecting the Iranian Health System Research and Technology Management. The CIA results of 89 factors affecting the Iranian Health System Research and Technology Management by 2025 were presented. The analysis of relation between these factors is presented in four categories: direct influences, indirect influences, potential direct influences, and potential indirect influences. Displacement of factors in each category is presented.

The primary data analysis of the CIA matrix showed that the matrix with two iterations had the 100% stability, indicating the high validity of the questionnaire used and its responses. The degree of fill rate the matrix was 58.9%, indicating that the selected factors had a relative impact on each other. Of 7921 relationships identified, 3252 relationships were equal to 0, meaning that the factors did not have any impact on each other or had not been affected by each other. Of the 4669 relationships which had influences, 1378 were equal to 1 – which means they had little impact in relation to each other, 1904 relationships were equal to 2 – meaning that they had a relatively strong impact in relation to each other, and 1169 relationships were equal to 3 – indicating that the relationships among key factors were enormous and they had strong influence or dependence. Finally, the number of potential influence (*P*) was equal to 218 – indicating the potential relationships among factors by 2025.

Direct influences

In this section, according to the level of identified factors' influence or dependence, they were categorized into the input factors, double-faced factors, resultant or depending factors, autonomous or excluded factors, and regulating factors. Table 1 presents the categorization of factors affecting the health system research and technology management based on the direct influences.

Figure 1 shows the direct influence and dependence of the identified factors based on the CIA.

The analysis of the indirect influences of studied factors on each other showed that two factors of the financial annex of the HSM and sufficient governmental budget allocation had the most and the strongest indirect influence on scientific authority. The displacement map of the influence and dependence of factors in the dynamic model of the health system research and technology management on the basis of direct and indirect influences [Figure 2] showed that the change in the position of the factors was not so high that it would make a significant change in their position, indicating the reliability of direct and indirect relationships among the factors affecting health system research and technology management. The most important point is that with regard to the potential direct influences, the improvement of the roadmap and the improvement of the government laws and regulations were as the second and third influential factors. Based on the potential direct and indirect influences, the change in the position of the factors was not so high that it would make a significant change in their position. In Figure 3, the map of the potential indirect influences among the factors affecting health system research and technology management has been provided at the 1% level.

Figure 4 and Table 2 represent the ranks and scores of the influences of the studied factors in the dynamic model of the health system research and technology management separately based on the direct and indirect influence, as well as potential direct and indirect influence.

Direct, indirect and potential direct and indirect dependence rankings

As shown in Table 2, the results showed that in the ranking of the first 10 factors, among the 89 factors

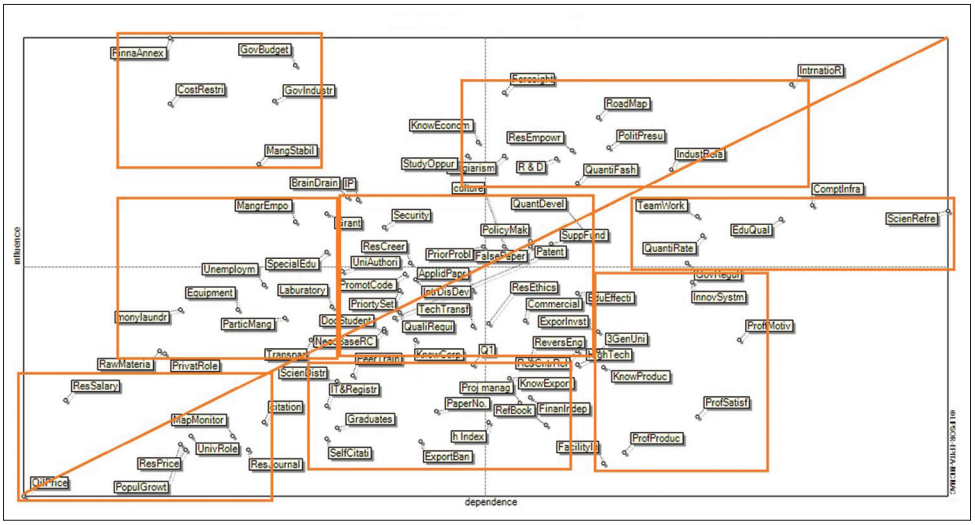

Figure 1: Direct influence/dependence of the identified factors based on the cross-impact analysis

Table 1: The categorization of factors affecting the health system research and technology management based on the direct influences

factors Category	Factors
Input factors (5 factors)	Financial annex of the HSM, sufficient governmental budget allocation, cost constraints, government-owned industries, management stability, and commitment
Intermediate or relay factors	
Stake factors (11 factors)	International communication, foresight and long-term planning, roadmap, frauds, research and development, empowerment of researchers, political pressures, university relationship with industries, adherence to the fashion and quantity, study opportunities, determining the share of knowledge-based economy
Target factors (7 factors)	Explaining the scientific authority, quality of education, empowerment of researchers, teamwork, governmental laws and regulations, quantitative ranking of science, competitive infrastructure
Resultant or depending factors (8 factors)	Integration of facilities, knowledge-based product, faculty members' productivity, faculty members and researchers' satisfaction, faculty members and physicians' motivation, innovation system, investment for export, third-generation university
Autonomous or excluded factors	
Secondary levers (11 factors)	Managers' capacity, specialized training courses, equipment, legal transparency, unemployed graduates, money laundering, internal and external grants, collaborative management, raw materials, review of the private sector role in health research and development, laboratory
Disconnected variables (13 factors)	Inappropriate distribution of scientific activities among faculty members, number of graduates, registry system, peer training, export sanctions, growth of the number of articles, H index, high-quality articles (Q1), reference books, projects and megaprojects management, knowledge-based exports, self-citations, financial independence of research centers
Excluded factors (8 factors)	Comprehensive monitoring of the HSM, the role of the universities in the HSM, researchers' salaries and income, scientific journals, population growth, oil price, citation rates, research cost price
Regulating factors (27 factors)	Effective education, number of doctoral students, scientific pathway of researches, promotion guidelines, prioritization of needs-based researches, university autonomy, participation in policy-making, determining the quality requirements of products, appropriateness of health care problems with priorities, culture creation, economic growth and security, interdisciplinary development, brain drain, integration of research centers, quantitative development beyond capacity, reverse engineering, applied articles, establishment of need-based research centers, patents, fabrications and false articles, research ethics, supportive centers and funds, commercialization, technology transfer, intellectual property, knowledge-based companies, export of high-tech products

HSM=Health scientific map

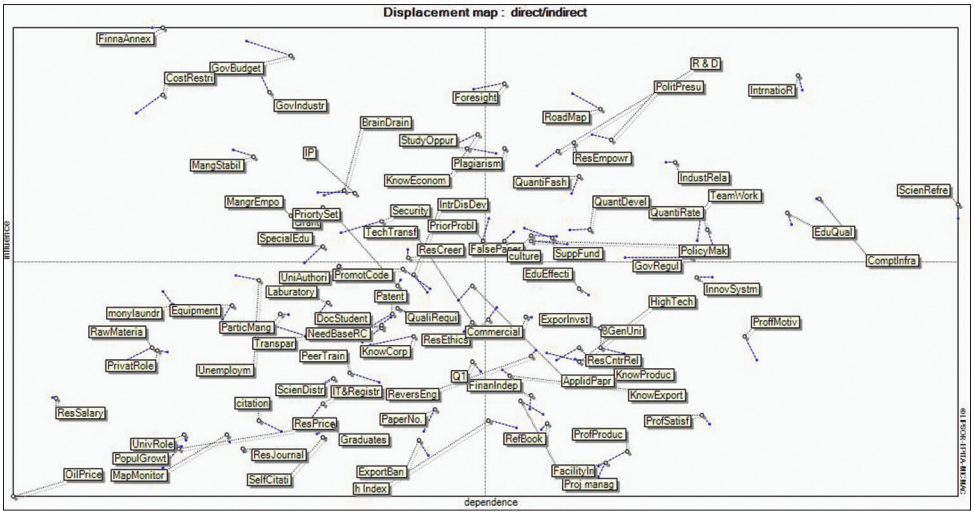

Figure 2: The displacement map of the influence and dependence of factors affecting health system research and technology management on the basis of direct and indirect influences

studied in the present study, five indicators of explaining the scientific authority, competitive infrastructure, international communication, university relationship with industries, quality of education, and faculty members and physicians' motivation had the highest dependence. In addition, the potential dependence ratings showed that explaining the scientific authority, international communication, university relationship with industries, competitive infrastructure, quality of education, and teamwork had the highest potential dependence. As shown in Table 3, the scores of the dependence of the studied factors in the dynamic

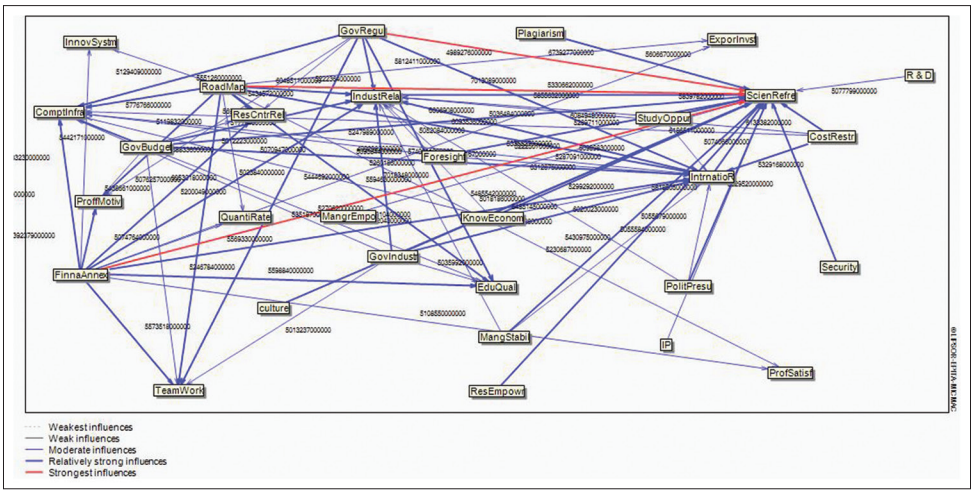

Figure 3: The potential indirect influences among the factors affecting health system research and technology management at the 1% level

Table 2: Ranking of 10 factors with the highest influence on health system research and technology management

Ranks	Factors	Scores of direct influence	Factors	Scores of indirect influence	Factors	Scores of potential direct influence	Factors	Scores of potential indirect influence
1	Financial annex of the HSM	219	Financial annex of the HSM	216	Financial annex of the HSM	210	Financial annex of the HSM	206
2	governmental budget allocation	208	Governmental budget allocation	210	Roadmap	205	Roadmap	206
3	International communication	200	Government -owned industries	199	Governmental laws and regulations	193	Governmental laws and regulations	198
4	Foresight	196	Foresight	192	Governmental budget allocation	193	Governmental budget allocation	194
5	Government -owned industries	193	International communication	192	International communication	192	Government -owned industries	186
6	Cost constraints	192	Roadmap	190	Cost constraints	188	International communication	182
7	Roadmap	186	Cost constraints	183	Foresight	182	Cost constraints	180
8	The share of knowledge-based economy	176	Political pressures	174	The share of knowledge -based economy	179	The share of knowledge -based economy	179
9	Political pressures	173	The share of knowledge-based economy	170	Government -owned industries	179	Foresight	179
10	Empowerment of researchers	172	Management stability	168	Study opportunities	177	Management stability	177

HSM=Health scientific map

model of the health system research and technology management have been presented separately based on the direct and indirect dependence, as well as the potential direct and indirect dependence.

Discussion

The CIA, as a foresight tool, can play an important and significant role in the development of the system in the future by identifying the role of a factor in relation to other factors within a system and categorizing factors.[5] In the present study, the CIA results of 89 factors affecting the Iranian Health System Research and Technology Management by 2025 were presented. The primary data analysis of the CIA matrix showed the matrix suitable stability and degree of fill rate (58%). This matrix with two data iterations had the 100% stability, indicating the high validity of the questionnaire used and its responses.[15,16,25] Most of the factors were located around the diagonal line of the scatter diagram and there were five key influencing factors in its northeastern part. Although there are studies with more factors,[2]

Table 3: Ranking of 10 factors with the highest dependence on health system research and technology management

Ranks	Factors	Scores of direct dependence	Factors	Scores of indirect dependence	Factors	Scores of potential direct dependence	Factors	Scores of potential indirect dependence
1	The scientific authority	223	The scientific authority	222	The scientific authority	217	The scientific authority	216
2	Competitive infrastructure	193	Competitive infrastructure	192	International communication	188	International communication	187
3	International communication	188	International communication	189	Relation to industry	186	Relation to industry	186
4	Quality of education	186	Quality of education	187	Competitive infrastructure	179	Competitive infrastructure	178
5	Faculty members and physicians' motivation	177	Faculty members and physicians' motivation	180	Quality of education	173	Quality of education	172
6	Quantitative ranking of science	169	Quantitative ranking of science	170	Teamwork	169	Teamwork	171
7	Teamwork	167	Innovation system	170	Research centers relationship	166	Research centers relationship	167
8	Researcher's satisfaction	167	Researchers' satisfaction	169	Physicians' motivation	164	Physicians' motivation	166
9	Innovation system	166	Teamwork	167	Governmental laws and regulations	157	Innovation system	158
10	Governmental laws and regulations	165	Research centers' relationship	160	Quantitative ranking of science	157	Researchers' satisfaction	157

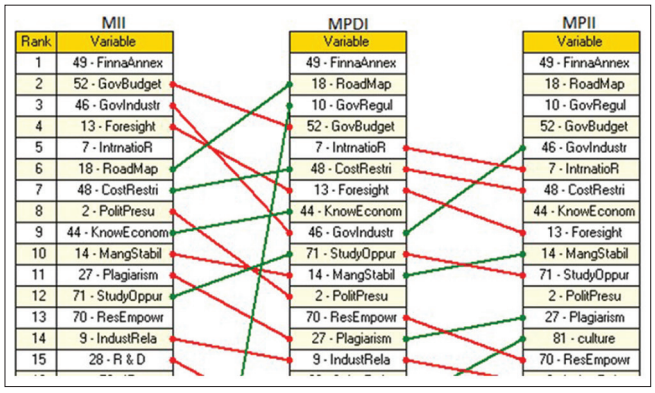

Figure 4: Ranking of 15 factors with highest ranks based on the matrix of indirect (MII), map potential direct influences, and matrix potential indirect influences

the number of factors entered into the CIA in the present study was relatively higher than many other studies,[20-23,26] which made the data collection and analysis more complicated. The degree of fill rate the matrix was desirable, indicating that the selected factors had relative influences on each other.[16,25] The scattering of the factors in the map of direct and indirect, as well as potential direct and indirect influences represented the system's instability.[15,16,25,27] System instability was mainly influenced by the intermediate or relay factors.[16]

Financial annex of the HSM, sufficient governmental budget allocation, cost constraints, government-owned industries, and management stability and commitment was factors with the greatest influence. However, in various studies, the importance of financing has been emphasized.[15,21-23,26,28] The results of the present study showed that the most influential factors affecting the health system research and technology management were factors related to the financing. The purpose of the financial annex of the HSM is to identify the financial consequences that can be used after conducting the necessary studies, based on the theoretical foundations and upstream documents, in particular, the HSM of the country, in accordance with the country's requirements and conditions, by providing practical financing solutions. It is a guide for managers and administrators to follow the strategies available in programs. The governmental resources constraints in a competitive world facing with financial and credit crises can lead to a crisis of efficiency and effectiveness.[29] It has been recommended that universities should review their management and financing methods, internal structures, and external relations.[30] In the present study, the management stability was also one of the important factors that needed attention. The results of studies have shown that the Iranian universities are often political and their management is often bureaucratic. This, due to the shortness of management life and frequent changes in regulations and bylaws, increases

the complexity, difficult conditions, confusion, and unplanned behaviors.[14]

Moreover, in the current study, explaining the scientific authority, quality of education, empowerment of researchers, teamwork, governmental laws and regulations, quantitative ranking of science, and competitive infrastructure were factors with the greatest dependence. Explaining the scientific authority was the most dependent factor. Scientific authority is a factor obtained through individual and collective as well as long-term endeavors in line with their own needs and their community needs for the production of science.[31,32] University relationship with industries was also one of the influential factors. The number of studies conducted by the universities and needed by the industries is low.[33] This problem is also a main problem in the health sector so that the health system has not used too much of the needs-based and health services market-based researches. The results of the similar studies also have shown the weaknesses in research and development activities, including studies on the need and capacity determination.[6] It is concluded that solving problems associated with the researcher such as the motivation to carry out applied studies, the appropriateness of education and research, the purposeful empowerment of individuals, setting the research priorities, and structuring the applied researches at the university is necessary.[14] Uncertainty about the intellectual property system of the universities can reduce the motivation and participation of faculty members.[14]

Policymaking and management, culture and norms as well as the development and promotion of education have great effects on the university performance.[14] The development and promotion of education through influencing the human resource performance can greatly affect the other challenges identified in this study. Providing legal infrastructure and creating laws and regulations and providing facilities needed at universities to commercialize research results are essential.[2,26,34] It seems that there has not yet been a proper and suitable platform for the health incubators' activities.[14] It has been said that in Iran, regardless of the infrastructure and prerequisites, the innovation system in advanced countries has been modeled.[14,35]

There are considerable challenges in the field of inter- and intra-organizational communication at the universities. The problem of universities on the path to globalization is their poor communication with the environment. This is evident in conducting the studies needed by existing organizations in the region and contracting with them.[36] Unfortunately, in developing countries, especially in Iran, due to numerous problems and barriers, such as poor communication, the knowledge of the university and industry of each other is not complete, and each one is engaged in their own activities on a separate path.[34] In order to improve motivation, it is necessary to appreciate the employees' desired activities.[37] In order to solve the problems associated with the researcher, some measures such as tailoring education to research and purposefully empowering the employees, setting the research priorities, and structuring the applied researches in the universities are necessary.[14]

Although the results of the present study are consistent with those of previous studies,[6,14,15,33,38,32] the distinction of the current study is its emphasis on the CIA of and ranking the factors affecting the health system research and technology management. The important points about potential direct influences which can be said are the improvement of the place of road map, as the second factor, and the improvement of the place of government laws and regulations, as the third factor. Developing a roadmap should be one of the priorities of managers. The necessity of designing a roadmap has been emphasized apart from the scientific road map.[8,13]

Financial annex of the HSM (S = 206), roadmap (S = 206), governmental laws and regulations (S = 198), and sufficient governmental budget allocation (S = 194) earned the highest potential influence scores by 2025. Furthermore, scientific authority (S = 216), international communication (187), university's relationship with industries (S = 187), and competitive infrastructure (S = 179) obtained the highest potential dependence scores by 2025. The improvement of the place of road map, as the second factor, and the improvement of the governmental laws and regulations, as the third factor, can indicate the potential role of these factors in the advancement of the health system research and technology management by 2025.

Conclusions

According to the results of CIA and with regard to the identified factors, which had the highest influence, it can be suggested that the financial annex of the HSM should be considered as the most important and effective aim of the health system research and technology management, and to ensure sufficient governmental budget allocation for research and technology management, careful planning should be done. Considering the indirect potential impact of the road map, it is suggested that a roadmap should be developed in line with the HSM. Furthermore, the policies on facilitating international communication should be made and the effects of foresight and long-term planning on the advancement of health research and technology management should be paid attention by the Ministry of Health and Medical

Education. Moreover, a plan should be made to ensure managerial stability and facilitate the university relationship with industries in the field of the health system research and technology management. It is suggested to the managers of the Ministry of Health and Medical Education that to achieve greater stability and progress by 2025, more attention should be paid to the intermediate factors in making policies and introducing regulations. It should be noted that the application of the present study results can also be considered in the Ministry of Science, Research and Technology. In addition, conducting scenario analyses of factors with the highest influence, including input, intermediate, and resultant factors can be suggested for the future studies.

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Conflicts of interest

There are no conflicts of interest.

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