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Providing a model for assessing the readiness of hospitals affiliated to Isfahan University of Medical Sciences in using the Internet of Things (IOT) Technology

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Abstract:

BACKGROUND: The Internet of Things is a revolution in health care both in the field of patient treatment and health information management. This technology can improve the status of patients, providing them with healthcare, collecting, sharing, storing and analyzing their medical information.

AIMS AND OBJECTIVES: Since the use of the IOT will create a wonderful future in the field of electronic health and the telecommunications industry, hospitals, health centers and policymakers in the health sector in the country should not neglect to get advantage of this technology. Therefore, this study aims to collect the necessary indicators for entering this technology and also measuring its preparation to use it.

MATERIALS AND METHODS: This is a practical research and in terms of information gathering, a descriptive survey type that describes and evaluates the preparation of IOT technology implementation in hospitals affiliated to Isfahan University of Medical Sciences. In order to measure the preparation for implementation of such technology in the treatment centers, a model based on the opinion of the experts in this area should be designed. According to which the model of this assessment in 5 different sections in the treatment centers that require this technology are also significant and Effective changes will be reviewed to assess their preparation.

RESULT: According to the standard coefficients obtained as a result of reviewing the opinions of the experts in this field, the most effective factor is "training of specialist staff in the university" and the least effective factor is "purchasing technical knowledge from universities and affiliated centers".

CONCLUSION: The results show that current hospitals are not prepared to move to this area and the universities should be able to enter the field quickly.

Keywords:

Hospital preparation, Internet of objects, modeling system

Introduction

Internet of Things (IOT) is one of the most important technological efforts in the performance improvement of medical centers such as hospitals, which leads to social justice in the field of health.^[1] IOT as a new tool in the field of information

technology has earned a special place in the health sector. The benefits of using this technology include reducing high costs of health-care services and reducing mortality rates from hospital infections.^[2,3]

IOT is considered as a revolution in health care both in terms of patient treatment and their health information management.

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This technology can improve the status of patients and provide them with health care; collect their medical information; and share, store, and analyze them.^[4] A health-care system based on the IOT offers an on-time service and saves the lives of millions.^[5]

The advancement and development of this technology has added a new section to the field of health and treatment called digital health advisers. This section can estimate health and social welfare through accessing medical data. Services that this section can provide include prevention of chronic diseases, providing dietary instructions, improving cognitive function, and achieving mental health improvement and life style improvements. This has led to an increase in the importance of the existence of this segment with the increases in the age of the global population.^[6]

It is well known that using the IOT and internet digital devices in various fields including health will not be without challenges.^[7] Technology implementation challenges in the health sector are the presence of various actors in the field, and the challenges have different shape and depth in different countries.^[8] These challenges can be the standardization of products and devices related to the IOT, applications, continuous monitoring, transfer of technology, discovery of new diseases and their daily consideration, and so on. Given the importance of IOT in the field of public sanitation and health, hospitals' mission in this critical field, due to the fact that so far no field study has been conducted around providing readiness for migration to this technology, as well as assessing this readiness in the field of public

sanitation and health, this study was conducted with the aim of creating a model to assess the readiness to use this technology in medical centers, which will have special importance.^[9]

The necessity of implementing the plan

In recent years, the development of the IOT which in fact is the physical connection of devices to each other and their virtual representation, has had a growing trend, whereby a wide range of new products and services and different potential areas have been created.^[10] Health sector is not exempt from this trend, as it is projected that by 2020, 40% of IOT technology will be related to the field of health.^[11-13] Hence, as the use of IOT will be the surprise in the field of e-health and telecommunications industry, hospitals, medical centers, and health-care policymakers in the country should not overlook the employment of this technology.^[14] Because in the close future, IOT will be considered as a leverage in the transformation of both financial (profit and growth) and nonfinancial (efficiency, productivity, and customer satisfaction) aspects of organizations and medical centers.^[15]

According to what was said, the predictive power of the IOT should not be ignored in the organizational performance of hospitals. This predictive power is not randomly created, but it is the result of collecting patient's vital signs continuously and periodically, continuous and periodic collection of specific parameters associated with common chronic diseases, follow-up and monitoring, remote services, information management, intelligent content sending to the user, interorganizational integration, environmental activities, etc.^[16,17] The

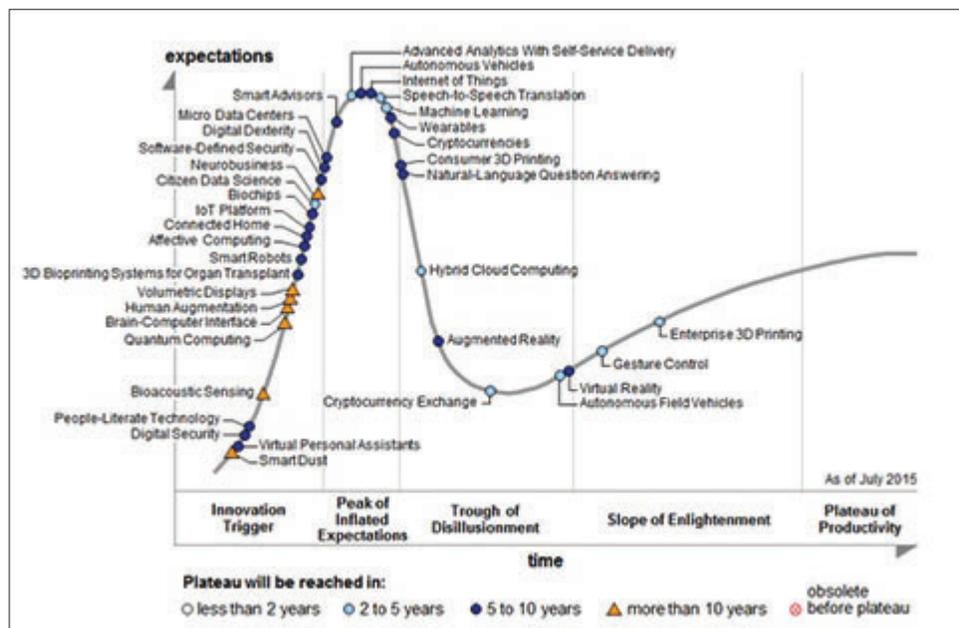


Figure 1: The evolution cycle of emerging technologies (Gartner, 2015)^[23]

convergence of these technology with medical informatics and health care can lead to controlling costs, reduction of inefficiencies, and cost-efficiency in living.^[18-20]

IOT is capable of medical data collection, storage, and reporting, and eventually creating the fittest strategies. That is why IOT must be considered one of the most important achievements of the modern technology.^[21] Of the most important positive outcomes of it, both physical and mental health of patients and cost-efficiency can be noted. In addition, the most important origin of the society, namely social justice, will be achieved, and the environmental situation and the collection of current abnormalities of hospital activities will be reduced to a minimum and will be controlled.

Theoretical foundations of research

The IOT has been the center of great attention in recent years, and in some cases, it is referred to as the fourth industrial revolution. The IOT is a concept rather than just a technology because it emphasizes the creation of a relationship between objects. Gartner in 2015 [Figure 1] claimed that this technology by being in the peak area of the cycle, came out from a mere concept and implemented to a limited basis by some organizations and companies. According to his opinion, it is expected that this technology will reach inclusive operational status over the next 5–10 years. The number of connected devices, the volume of investment, and the economic value of activity in the IOT are considered as important indicators of the development of this technology in resources, and credible reports and different numbers are listed for them. Based on Cisco Report 2016, the number of connected devices through the IOT has been around 26 billion units in 2015, and will increase to 50 billion by 2020.

According to the status and effectiveness of this technology in the country, studying different aspects of the effects of IOT in Iran is being carried out in the project “roadmap codification of the IOT.” Investigating the status of Iranian companies active in the field of the IOT is one of the most important tools for data collection and monitoring capabilities at the enterprise level. Therefore, the results of this research can provide the basis for decision-making and adopting the right and empowering policies in health care.

Measuring the IOT technology in Iran

Several indicators have been emphasized for monitoring and assessing the overall impact of the IOT at the international level. To understand the contribution of any industry or technology to the growth and development, the produced economic value, the impact on the environment, and the contribution to entrepreneurship and economic prosperity, the above parameters should be monitored.

The decisive question is that how an index is significant in a country. Selection of appropriate indicators and metrics, certainly, can be of great help as the basis for measuring the success and movement in the right direction of a new process. According to a survey conducted, seven indexes are set as the proposed indicators: (1) human force readiness, (2) supervision readiness, (3) readiness for cooperation of various sections, (4) technical and infrastructure readiness, (5) supportive readiness, (6) financial and investment readiness, and (7) research readiness.

Sustainable development indicator is one of the most comprehensive indicators that is respected across the world today. This index not only focuses on the economy, but also emphasizes three basic matters of economic, social progress, and environmental care increase. The IOT can take in hand up to about 6% of the world’s economy in 2020. Therefore, so many institutions have identified and categorized these industries.^[22] If such a prediction comes to the truth and this technology creates around 8.1 trillion dollars’ worth of economic backgrounds by 2020, developing strategies to exploit it will be necessary more than ever.

A survey was conducted in 2016 to investigate the use of IOT in various industries in Iran.^[23] The survey results were related to the Telecom Expo 2016. The results of this survey for the different areas were as follows: health (17%), manufacturing and production (10%), banking and insurance (13%), transportation (16%), information and communication technologies (ICT) (36%), and agriculture and animal husbandry (8%). With some differences in the status of industries (predicted by different institutions for the year 2020), the results confirm that the industries of health, transportation, banking, insurance, and intelligent manufacturing and production will stimulate the development of the IOT in the world. The reason for differences of Iran’s ranks with other countries can be found in the economic structure of these countries. According to World Bank and World Economic Forum studies, countries follow their macroeconomic patterns.^[23] The reason for it not being welcomed in other industries is known to be in some cases: (a) the use of the IOT is not fully known for Iranian companies; (b) industries have not been selected correctly and according to Iranian companies, and there is no other option; and (c) the supply and demand market for other industries is very vague and ambiguous because of nonclarity in market size and potential economic value; companies have avoided entering to a specific risky market. However, other cases such as unavailability of technology and lack of supportive systems can be verified.^[23]

Materials and Methods

This study is functional in terms of aim and descriptive type of scaling using data collection method, which provides the description and assessment of readiness to implement IOT technology in affiliated hospitals of Isfahan University of Medical Sciences. In the first step of this research, previous related researches were studied. In the process of conducting this research, concepts, frameworks, concepts related to IoT and hospital jobs in using this new and efficient technology were examined and evaluated. Then, various budgets that help in the adoption of this technology were studied and their combination with the extracted indicators related to the readiness of IoT technology is presented.

In the next step, in order to validate and refine the model, a questionnaire was designed in the form of 5-item Likert quality questions from “very low” to “very high” and questioned by bringing together the experts. According to the opinion of these experts, the proposed reform model was reduced (from 8 main indicators to 7 indicators and from 54 to 24 main categories). The results were analyzed using factor analysis method using software SPSS (IBM Company) and LISERT, the final version was resulted and priority and weight parameters were also determined with the help of LISREL. Finally, in order to determine readiness, based on the model developed, a questionnaire was designed and set in

possession of 200 employees and managers through the direct method (in person) and the target readiness statistic was extracted.

Statistical analysis

The target population for modeling was all the experts, scholars, and professionals in the field of university informatics and hospitals such that 82 people were identified. In this study, the census method was used to collect data in which all individuals were selected and 82 questionnaires were handed to them and finally 78 questionnaires were completed. The questionnaires were first sent to all members of the society through E-mail with several repeating stages, but after a month, the need face-to-face interaction with experts in this area was felt to obtain more effective results.

Results

In this section, based on the conceptual framework of the IOT implementation readiness assessment, different layers of model were introduced in the LISREL software as follows and were analyzed with the data obtained from the questionnaires:

(a) IOT implementation readiness layer, (b) the main seven aspects of model layer (“personnel readiness,” “monitoring readiness,” “readiness to cooperate,” “technical and infrastructure readiness,” “supportive readiness,” “finance and investment readiness,” and “Research readiness”), (c) 24 indicators of model layer, and (d) indicators’ layer (questions).

In this study, for hospital-dependent variables, IOT implementation readiness 24 visible and measurable variables are considered. The relative coefficient between independent and dependent variables (data coefficient), which is called path coefficient in analyzing the path, shows that how the change in the variable at the end of the arrow can affect the variable at the arrowhead.

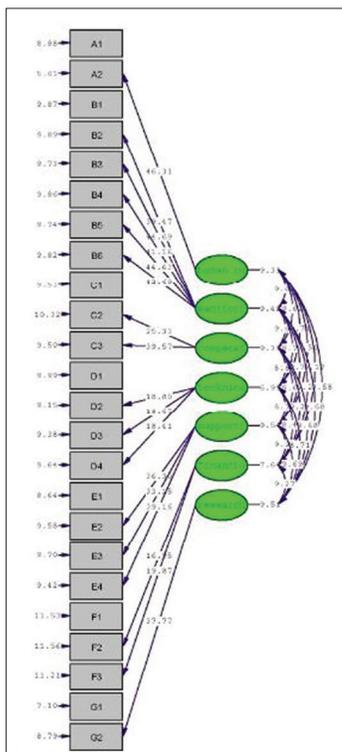


Figure 2: Path analysis diagram

Table 1: Fit Indices

Ideal score	Points	Fit indices
$P > 0/9$	9/01	NNFI
$P > 0/9$	0/95	IFI
$P > 0/9$	0/91	RFI
$P > 0/9$	0/92	NFI
$P > 0/08$	0/045	RMSEA
$P > 0/05$	0/019	RMR
$P > 0/9$	0/95	AGFI
$P > 0/1$	0/075	SRMR
$P > 0/9$	0/95	PGFI
$P > 0/9$	0/98	CFI
$P > 0/9$	0/97	GFI
$P < 3$	2/983	χ^2/df

Relation assessment

Based on confirmatory factor analysis model provided in Figure 2, the existence of a meaningful relationship between the different layers of the model is indicated using standardized coefficients of confirmatory factor analysis. The larger the standardized coefficients are, the greater the impact will be on the desired factor. If there is a negative sign in the standardized coefficients of some indicators, then these coefficients are interpreted as their indirect relationship.^[24] According to the standard coefficients shown in Figure 2, the readiness of IOT application had the most effect after “specialist human resources training at university,” with a standard coefficient of 46.31 and the least impact after “buying technical knowledge from universities and affiliated centers,” with a standard coefficient of 16.95. Accordingly, the results of the evaluation of the adequacy of the model (suitability) and the evaluation of the relationship between the various factors of the model were extracted as follows.

Assessing the suitability of the model

To assess the appropriateness of the confirmatory factor analysis model, fitness indicators are used,^[25] which are presented in Table 1. In addition, to get the coefficient of the importance of indicators on impacting factors, the path analysis (standardized, or beta multivariate linear regression coefficients) is used.

Final model of research

Based on the results of the local and approved model, from the original dimensions, the “specialist human resources training at the university” aspect from the Personnel Readiness Index had the highest weightage, and the “buying technical knowledge from universities and affiliated institutions” aspect from the Financial Readiness Index had the lowest weightage.

These results indicate that the beliefs of experts and professionals are that the readiness to use IOT requires implementing and training this new technology in university topics, which can double the importance of discarding traditional practices that are often considered inefficient.

Monitoring readiness is also in second rank in importance, which reflects the importance of law codification, regulations, and standards required for implementing this technology in the field of health care and community treatment. Interestingly, and of course, a surprising point is that the technical and infrastructure dimension had the

lowest coefficient, and according to what experts have declared, this index is one of the most important indexes in the implementation of this technology, but as long as there is no expert trained in this field and the legal base is not provided yet, this important indicator will be lowered to the bottom itself. These findings state the beliefs of internal experts with respect to local conditions of the country, they confirm the locality of model and with the change of specialists, the results and priorities of this research will also change.

Assessment of the readiness of the implementation of Internet of Things Technology in health centers

To assess the readiness of implementation of IOT technology in hospitals, Likert questionnaire of analytical type and by doing a field study, reviewing the documents, conducting interviews, and a survey of 200 hospitals’ personnel with statistical analysis, the readiness rate of IOT technology application was evaluated.

The designed model was used to determine the readiness rate. For this purpose, first, characteristics and related measures for the indices and subindices of the model were determined, suitable questions for measuring the target were designed in the form of five worksheets, and the designed questionnaire was confirmed by some of the experts. To make ease of responding to questions, all questions were introduced in the qualitative form (by Likert). Worksheets 1–5, respectively, were collected for the evaluation of IOT readiness in reception and medical records unit, finances and administration, informatics, pharmacy, and imaging using field methods between population communities at medical centers.

Calculation method: First, to transform the qualitative values of the indicator to quantitative values, grading and standardization of the questionnaire was conducted, as shown in Table 2. In addition, the scores obtained from the research were calculated and extracted as follows:^[24]

- a. Calculation of the readiness of hospitals: In this stage, the readiness of each factor is calculated using the following equation (Equation 1):

$$I_m = \sum_1^i W_i X_i$$

I_m : Readiness rate in factor m , i : The number of indexes of each factor, X : The value of each index (which is obtained from the average of the responses given to each indicator), and W : The weight of each index, which is normalized with the following equation (Equation 2):

$$W_j = \frac{W_j}{\sum_i W_j}$$

- b. Calculation of hospital readiness in the main aspects: At this stage, the readiness level of the main aspects is calculated using the following equation (Equation 3):

Table 2: Scoring questionnaire questions

	Very low	Low	Medium	Much	Very much
Raw score	0	1	2	3	4
Standard Score	0	2/5	5	7/5	10

Table 3: Measuring the preparation of using the IOT technology

Dimensions	Readiness dimension (from 1)	Dimension weight	Standardized weight dimensions	Factor	Hospital readiness (from 10)
Preparation of hospital staff	3/53	0/98	0/178	Ready to use IOT	3/67
Regulatory preparation	3/23	0/99	0/180		
Preparation for cooperation	5/25	0/57	0/178		
Supportive preparation	4/40	0/89	0/136		
Technical readiness and infrastructure	2/15	0/75	0/180		
Financial and investment readiness	3/67	0/64	0/116		
Research preparation	4/37	0/68	0/124		

IOT=Internet of things

$$I_d = \sum_1^i W_i I_m$$

I_d : The number of components of each dimension, i_d : The readiness level in d dimension, I_m : The readiness level of each component (which can be obtained from Equation [1]), and W : The normalized weight of each component.

- c. Calculation of the IOT technology application readiness index: At this stage, the readiness value is calculated using the following equation (Equation 4):

$$I_{e_readiness} = \sum_1^i W_i I_d$$

I : Number of dimensions, $I_{e_readiness}$: The amount of readiness index for IOT technology application, I_d : Readiness level in each dimension (that will be obtained from Equation 3), and W : The normalized weight of each dimension. The score of the hospital in the readiness of the IOT technology application could be between 0 and 10, that the closer the readiness score to 10 is, the higher the readiness will be.^[26] The e-readiness of hospitals in the component under consideration is introduced in Table 3.

As shown in Table 3, the “co-operating readiness” aspect is more than all other dimensions with the score of 5.25, followed by the dimensions of “readiness to support” with the score of 4.40, “research readiness” with a score of 4.37, “financial and investment readiness” with a score of 3.63, “personnel readiness” with a score of 3.53, “monitoring readiness” with a score of 3.23, and “technical and infrastructure readiness” with a score of 2.15.

Barriers to activities in the field of Internet of Things in health centers

To provide services in the field of health care, there is a need to suppliers in various technical and infrastructure sections, including sensors, components, devices, networks, communication; without these essential sectors, the IOT space would not be definable. On the other hand, despite all these options, as the IOT is a new paradigm, its space is relatively unknown and even its business models are not well known, so there is a need

for research and development centers, academic training, as well as financial support, counseling, and laboratory services.

It is noteworthy in this observation that the relative importance of competitors in the IOT space is low, because over the past decades, due to the sanctions and unfavorable economic conditions, Iran has faced a justifiable backwardness in entering this area and using its benefits in the health-care sector. In addition to all of the above, one should not forget that the IOT is defined by the ecosystem of roles, and each department and organization in interaction with another can benefit from synergy in this area. Consequently, defining roles individually or in isolation cannot be accountable in this space and would not create value. Therefore, training of specialists in the university, on the one hand, and the support of the government and the authorities and the attraction of capital, on the other hand, will all be effective together.

Conclusion

The activity of affiliated hospitals in the field of the IOT as an emerging technology requires necessary preparations. In this regard, the University of Medical Sciences, as the upstream of the affiliated treatment centers, has problem in providing funding, gaining creative ideas, designing new products and services, establishing specific regulatory rules, and providing expert human resources. Providing R&D costs, purchasing equipment and machinery, and equipping laboratories to test the products and services of the IOT all require financing from which the universities and hospitals can directly allocate from their sources of income or through an external source such as banks and sponsoring organizations for risky investments. According to the results of the assessment of the readiness to enter the IOT-based approach to the benefits of it, there are still no long-term, well-defined, and applicable planning decisions in this area, and it is clear that the university as an influential institution and the implementer of such an approach should quickly take early steps and reduce the gap between the traditional

approach and the technology-based approach over a long-term plan.

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Conflicts of interest

This article has conflicts of interest from the mentioned research center.

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