An Evaluation Model for the Implementation of Hospital Information System (HIS) in Public Hospitals Using Multi-Criteria-Decision-Making (MCDM) Approaches

Abstract

Hospitals implement Hospital Information System (HIS) to improve the efficiency and effectiveness of their healthcare professionals as well as to meet requirements for high quality patient care. To identify significant factors that influence the hospital decision in adopting the HIS, our study reviewed an extensive literature on health innovation adoption and integrates the framework of Technology-Organization-Environment (TOE) which is known as a mature framework and Human-Organization-Technology (HOT) fit model. For that reason, a hybrid Multi-Criteria-Decision-Making (MCDM) model is employed to provide the evidence of significant dependence relationships of factors by using Analytic Network Processes (ANP) and Decision Making Trial and Evaluation Laboratory (DEMATEL) methods. Hence, this study designs the initial integrated model by taking the three main dimensions with related 10 variables as potential organizational factors of adoption regarding the HIS technology. Accordingly, DEMATEL are utilized to test the strength of interdependencies among the dimensions and variables. Then ANP approach is adapted to elucidate the imperative status of adoption factors, and utilized to determine how the factors are weighted and prioritized by professionals and main users working in the Iranian public hospitals, involved with the HIS system and having experience in HIS decision making. The results indicate that "Perceived Technical Competence" is a key factor in the Human dimension. The respondents also believe that the "Relative Advantage", "Compatibility" and "Security Concern" of Technology dimension should be further assessed in relation to other factors. With respect to Organization dimension, "Top Management Support" and "Vendor Support" are considered more important than others. Additionally, this study found that the respondents perceived the Technology and Human as the most important dimensions in HIS adoption. Applying the TOE and HOT-fit models as the pillar of our developed model with significant findings adds to the growing literature concerning the factors associated with the adoption of HIS and also shed some light for managers of public hospitals in Iran to successfully adopt the HIS. Notably, this was the first theoretical study contributed to determine the strength of factors affecting the HIS adoption in public hospitals in two cities of Iran, Bandar Abbas and Qeshm.

Keywords: Hospital Information System (HIS), Adoption model, Iranian public hospitals, TOE framework, HOT-fit model, ANP, DEMATEL

1. Introduction

Rapid changes in the healthcare delivery system throughout the world have been possible by the advancement of Information System (IS). The increasing attention given to implementing a Hospital Information System (HIS) in hospitals particularly on the need to consider the acceptance and usage of HIS amongst healthcare professionals [1]. Hospitals by adopting Information Technology (IT) applications such as HIS would gain the great benefit, ranging from medical systems to administration systems. HIS is broadly employed in the hospitals around the world [122, 39, 37]. HIS was first introduced in the 1960s to support hospital's financial services [99]. Subsequently, in the 1980s, it was used in clinical services where a large amount of laboratory examination data was stored electronically [118]. Since the HIS assists healthcare providers to streamline the flow of patients' information and its accessibility, the significance of the HIS in providing high quality patient care has grown [99, 39, 109, 110]. Therefore, implementation of HIS becomes fundamentally crucial in making the right diagnostic, treatment and administration requirements, and thereby in delivering better patient care and support to clinical decision making [117, 58, 111]. Even though the HIS has brought the immense change to process of care delivery, it has attempted to increase the quality and safety

of care [2, 120, 99, 119, 1]. However, compared to other technologies in the healthcare domain, the acceptance level of HIS is low [58, 46, 121, 122, 142].
HIS can do support patient care planning and enhance decision making of clinical or administrative functions. Besides, there are some limitations in the clinical practice that are being addressed via the HIS implementation [130, 123, 122]. As an example, HIS systems used by nurses are able to control and track carefully the patient's care in an electronic manner. Additionally, nursing documentation as a chief clinical activity, stand to obtain benefit from HIS [112, 113]. Thus, it is imperative that HIS is designed to address the needs of main users in optimally coordinating user activities.
At this time, IT priorities serve to alleviate medical errors, upgrade in-patient clinical systems and implementing HIS in the hospitals [114]. Although the potential benefits of HIS in public hospitals are highlighted, no comprehensive theoretical assessment of HIS implementation in Iranian public hospitals has been done. Iran is a developing country that introduces national plans including SEPAS and TAKFAB as well as organizational e-Health projects for instance HISs in hospitals that are under development. According to several authors in Iran [121, 125, 126, 127, 124, 122], the challenges of HIS implementation in Iran relates to some fundamental issues of Human, Technology and Organization. Hence, this study aimed to propose a strategic integrated theoretical model to serve in guiding a proper and successful HIS implementation within public hospitals.
Considering that there are no comprehensive studies on the HIS adoption maturity model and professional knowledge in this area with regard to Iranian public hospitals, this study was designed based on the two mature theories to identify the significant dimensional factors of HIS adoption and their important interrelationship in two different public hospitals and also to provide some suggestions to enhance their HIS implementation. Hence, the questions that guide us to achieve the main study goal, are: (a) What significant factors can affect the decision to adopt the HIS based on TOE and HOT-fit model? (b) What is the appropriate theoretical model that can be used to ease the HIS adoption? and (c) What MultiCriteria Decision-Making (MCDM) model is appropriate to weigh and prioritize the factors for HIS adoption in Iranian public hospitals?

2. Literature Review

2.1 HIS Definition

Several definitions have been provided pertaining to the HIS. According to the National Library of Medicine [115], HIS is "the integrated, computer-assisted system designed to keep, manipulate, and retrieve information concerned with the administrative and clinical aspects of providing medical services within the hospital." In addition, according to Ismail et al. [46], HIS is defined as a computer system by which the whole administrative and medical data of a hospital is managed to make the career of health experts well-organized and operational. In another definition by Kim [52], HIS has been defined as "a designer computer system devised to enhance the clinical and administrative functions of a hospital." He further added that "HIS is required by the nature of its function to be integrated, and hence is referred to an integrated hospital information processing system." Referring to several definitions of HIS, the present research defines HIS as a comprehensive, integrated information system designed to enhance clinical, financial and administrative functions of a hospital.

2.2 Adoption of HIS

The term, adoption is about the decision of any individual or organization to make use of innovation [116, 30, 81]. In the organizational context, adoption is associated to admitting a new innovation for implementation [24]. In addition, in terms of technology adoption in the organizational context, Gallivan [31] and Lin et al. [61] defined adoption as employing a new technology in organizational work and encouraging employees to oblige in applying the technology. As such, in terms of the research topic, adoption refers to the decision of employing HIS in the public hospital work practices and encouraging healthcare professionals to apply HIS.

2.3 Innovation Adoption in Organizations

Organizational innovation has been generally defined as an idea, system, practice, product or technology that is perceived as new by an adopting organization [81, 18, 105]. A type of innovation may be novel for an individual adopter, the majority of individuals at that unit of adoption, for the entire organization, and for the majority of organization in the population of an organization or for all the world [75, 20]. Consequently, innovation has been studied at various levels [91].
The present study focuses on innovation through HIS at the organizational level. Thus, following the above, HIS can be considered as innovation for hospital's organization, if the hospital organization perceives HIS as new. Hence, the organizational innovation theories can be potentially useful to this research development of a new model of HIS adoption. Generally, studies on technology adoption and diffusion in the area on IS are conducted in two levels, user level and organizational level [116, 16]. Furthermore, the stage of adoption and the context of study should be carefully paid attention to, especially in the technology and innovation adoption studies [16]. This study is based on the organizational innovation, which is intended to seek potential dimensional factors that can influence the HIS adoption by Iranian public hospitals. Hence, the organizational innovation theories and models along with the existing HIS literature might help to achieve identifying these significant factors that affect the HIS adoption in the context of public hospitals.

2.4 Adoption Theories in IS Domain

Studies on technology adoption of innovation has been a long source of research across various IS domains [86]. Historically, adoption/diffusion theories have similarity in content and objectives, but some differences exist in practice [86]. The purpose of theories of adoption in IS disciplines is to understand, explain, or predict how, why and to what extend individuals or organizations will adopt and decide to deploy a new technology [16]. In the broadest sense, adoption theories describe the significant factors influencing technology adoption by individuals or organizations. Thus, adoption theories are aimed at recognizing and examining all these determinants [54]. In contrast, diffusion innovation theories illustrate how an innovation can spread throughout a population over time [86].
According to Wolfe [101], in previous studies related to IS, several theories and models on innovation have been determined and used in various situations. Major differences can be observed with respect to the level of analysis such as individual level versus organizational level, unit of analysis such as individual versus the

innovation versus the organization, and the outcome variable such as use versus adoption. Given the aim of this study, several theoretical models have been assessed on their applicability in investigating factors that have effects on HIS adoption in the context of hospital organization. Several adoption/diffusion theories in IS research have been proposed to make the understanding of factors affecting adoption and acceptance of particular technologies easier. In general, the researchers have investigated two levels of innovation adoption: the individual and the organization.

At the individual level, Technology Acceptance Model (TAM) [21], Theory of Planned Behavior (TPB) [3], Unified Theory of Acceptance and Use of Technology (UTAUT) [100] and Rogers' early Diffusion of Innovation (DOI) theory [81] are the most commonly-used adoption/diffusion theories in IS research [74, 27, 86]. Although such models are very useful and important, their main focus is on users (individual-level) as well as technological attributes, while they fail to consider the attributes related to organization [101]. In particular, the first three theoretical models can only be used at individual level [100], whereas DOI theory can be used at individual level as well as at organizational level [34, 19].

At the organizational level the most frequently used adoption theoretical models, Diffusion of Innovation (DOI) theory [81] as well as Technology-Organization-Environment (TOE) framework [96] are most widely used [74]. DOI theory has been frequently employed to investigate drivers of innovation adoption, since it can be used at individual level as well as at organizational level [34, 19]. More attention has been given to TOE framework and it is accepted from diverse fields of study as it creates Rogers' DOI theory more capable of explaining organizational innovation adoption by including an important novel component: environmental dimension [74, 40].

A lot of research works which have empirically examined the TOE framework, revealed that the TOE framework importantly helps to understand the adoption of technological innovations [27, 74, 133]. In many noticeable researches conducted on the basis of TOE framework, factors which are crucial in information system's adoption were carefully investigated. This is also the case for different health information systems [102, 27, 74, 116]. However, regarding the context of sensitiveness and complexity of technology adoption, different factors in TOE framework may vary across different innovation and adoption contexts [27, 96]. Consequently, even though there are various studies adopted TOE framework for investigating organizational adoption of health information system, this framework has not been scrutinized within the domain of HIS adoption by Iranian public hospitals particularly in two cities of Bandar Abbas and Qeshm. According to the above discussion, DOI and TOE are the most commonly-used adoption theories in the IS discipline with respect to the organizational innovation adoption. As such, the researcher in this study examines their ability to explain the HIS adoption.

2.4.1 Technology-Organization-Environment Framework

The TOE framework as presented by Tornatzky and Fleischer [96], gives a proper analytical framework that is applied for examining the organizational adoption of diverse types of innovations [74, 131]. This framework has focused on analysis of organizational level that is as a lens to predict adoption decision of technology. It covers three different dimensions. They are described as technology, organization and environment. As illustrated in Fig. 1, the three dimensions interact with each other, and influence decision-making about technological innovation adoption.

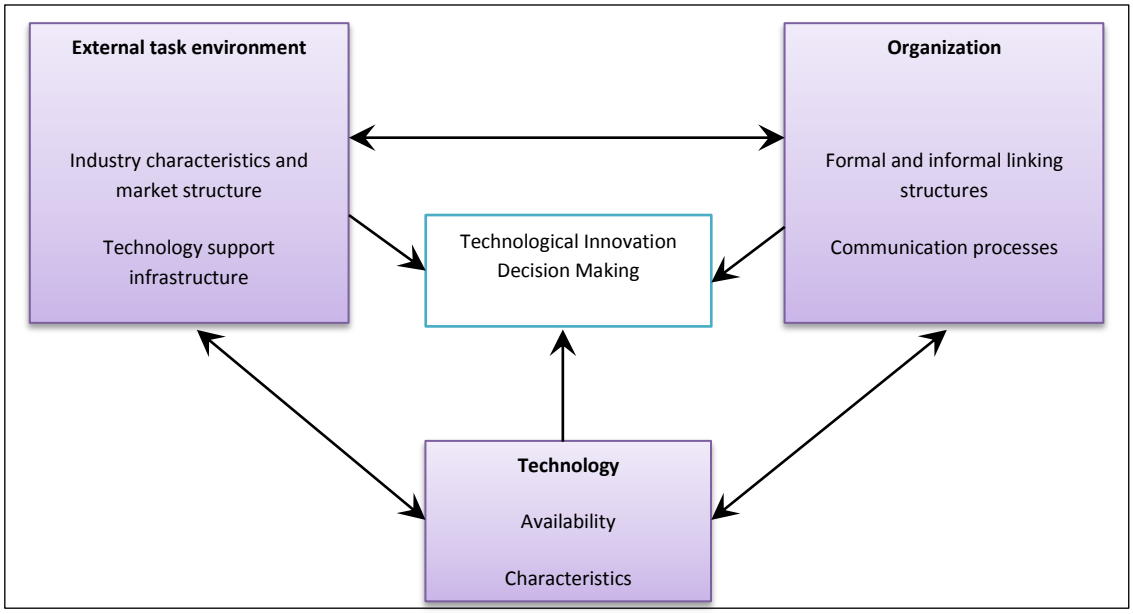

Fig. 1. The TOE Framework [96]

Technological dimension describes new/current and external/internal technologies which are related to organizations (e.g., compatibility, complexity, and relative advantage). Technological dimension consists of both technologies to be adopted and existing technologies, and primarily emphasizes on the way that adoption process is affected by the technological characteristics [96]. The organizational dimension provides a description of characteristics of an organization that facilitates or constrains adoption of technological innovations. The amount of slack resources available internally, the quality of human resources, top management support, organization structure, and firm size are the instances of organizational characteristics.

The external environmental dimension concentrates on firm environment that belongs to different stakeholders with which it interacts. TOE framework has been employed by many empirical studies to better understand the organizational decision of IS adoption (see Table 1). Those studies identify different significant adoption factors pertaining to the three dimensions of the TOE framework that are summarized in Table 1. DOI theory and TOE framework are largely compatible. TOE framework does not only consist of technological dimension that is parallel to the one category in Rogers' model, it also has two significant and innovative components: organizational and environmental dimension. Rogers' DOI theory provides a more inclusive description of organizational innovation adoption through TOE framework [116, 74, 40].

There are many evidences of TOE framework that is applicable and has explanatory power throughout various contexts. It has been applied to understand the adoption of many IS applications or technologies such as inter-organizational systems, e-business, electronic data interchange, open systems, and enterprise systems. However, each study used slightly different factors as measures for each of the framework's dimensions [27, 122]. In addition, according to Table 1, it can be demonstrated that in order to explain the adoption of several diverse IS innovations, TOE framework can successfully be utilized. Likewise, the TOE model was applied

and tested in Asian, European, and American, in addition to both developed and developing countries [27, 106, 107, 108].

To all intents and purposes, the experts generally agree on the three TOE dimensions suggested by Tornatzky and Fleischer [96], including the effect of environment, organization and technology adoption. However, they asserted that a set of measures or factors for every certain dimension or technology under research are irreplaceable.

Table 1. Research using TOE framework in IS domains

Dimensional Factors within TOE	Frequency & Relationship Direction	Author(s)
Technology		
Relative Advantage	10 (+)	[23, 32, 73, 54, 15, 93, 45, 64, 133, 143]
Compatibility	6 (+)	[23, 73, 93, 35, 64]
Complexity	6 (+)	[93, 35, 78, 60, 10, 44, 143]
Trialability	1 (+)	[23]
Perceived Barriers	1 (-)	[12, 13]
Perceived Risks	2 (-)	[42, 91]
Organization		
IS Infrastructure	8 (+)	[90, 7, 52, 38, 103, 83, 13]
Size	6 (+)	[93, 78, 106, 53, 89, 72]
Top Management Support	6 (+)	[9, 77, 49, 89, 78, 133]
Satisfaction with existing Systems	1 (-)	[12, 13]
Financial Resources	3 (+)	[32, 23, 54, 143]
Environment		
Business Competition	4 (+)	[78, 54, 108, 35, 133]
GovernmentPolicy	3 (+)	[10, 54, 108]
Market Uncertainty	1 (+)	[12, 13]
Customer Readiness	1 (+)	[106]
Vendor Support	1 (+)	[78]

According to Table 1, certain factors which are suggested to be associated to three dimensions are dissimilar as discovered in various researches. However, there is a reliable empirical support for the TOE framework. Fichman [29] reviewed available research on IS adoption, and found out that organizational adoption of IS innovation is affected by those three characteristics. Therefore, TOE framework can be considered a suitable inclusive theoretical guide that can help organizations to explore the factors having impacts on implementation of IS innovation.

2.4.1.1 Critical Analysis of TOE Framework in the Domain of Health Information System

Using TOE framework [96], succeeding the IS adoption in the context of healthcare industry on many circumstances becomes easier [123, 60, 61, 62, 44, 39, 43, 10, 50, 57, 11, 59]. As an instance, in the healthcare industry, Chong and Chan [141] conclude that TOE framework is capable in assisting to clarify the notion of RFID (Radio Frequency Identification) adoption. In another work, Liu [62] employs TOE framework to understand telecare adoption in Taiwanese care institutions. The study of Chang *et al.* [10] indicates that the TOE framework is useful to identify e-signature adoption factors within a hospital setting. In addition, Lian *et al.* [60] used the TOE to understand the critical factors, which can influence cloud computing adoption in the hospital context. They believed that TOE framework is suitable and can be utilized for healthcare industry in understanding the adoption of IS innovation. Ahmadi et al. [110, 122] strongly believed that TOE framework is a potential lens that can appropriately analyze the context of hospital technology adoption. Authors applied this framework to explore the significant dimensional factors influencing the HIS adoption in the context of Malaysia. Considering technology adoption that is sensitive to setting and very complicated, several factors in TOE framework may vary across different innovation and adoption contexts [27, 96].

In our study, health information system's works were reviewed with respect to the hospital setting and hospital innovation adoption based on TOE framework, hence, Table 2 was presented. On the basis of particular circumstances and various requirements of healthcare context, the potential variables for those dimensions of TOE including the technology, organization and environment were assessed. In this table, factors that empirically influenced on the healthcare IS innovation adoption is shown, in which asterisk indicates the most influential factors, plain text mentions the factors for which partial support were found, and italic shows the factors that were not statistically important.

Table 2. The utilization of TOE framework in hospital information system domain

Author(s)	Hospital Technology	Technological Dimension	Organizational Dimension	Environmental Dimension
Hsiao et al. [39]	Mobile Nursing Information Systems (MNIS)	*cost benefit, mobile devices suitability, wireless communication suitability, the extent of integration with HIS,*	*Top management support, project team 's capability, user involvement and cooperation,* Championship, internal needs*	Business competition*, *government policy support, e*xternal supplier‘s support*
Chang et al. [10]	Electronic signature	*System complexity, Security protection*	*User involvement,* adequate resources*, hospital size*, *internet need*	Vendor support*, government policy*
Chang et al. [11]	Picture Archiving and Communication System (PACS)	*Cost of PACS, compatibility,* benefits of PACS*	*Centralization, Formalization,* high-level manager support*	*Business competition,* governmental policies*
Lee and Shim [57]	RFID	Vendor pressure, Perceived benefits*	Presence of champions*	Performance gap*, market uncertainty*
Yang et al. [102]	Healthcare information systems	Technology readiness/receptivity, relative advantage*, complexity*, compatibility*	*Hospital type, hospital ownership, hospital size,* internal needs*, resource availability*, technological knowledge*, knowledge management capabilities, project team capability*, top management support*	Government involvement*, vendor partnership*, *business competition pressure, country wealth*
Lin et al. [61]	HL7	*S*ystem integrity*, *security*	Staff‘s technological capability*, hospital‘s scale*, top Management attitude toward HL7*	*Push of the environment,* environmental pressure*, pull of the environment
Ahmadi et al. [110]	HIS	Relative advantage*, complexity, compatibility	Centralization, formalization, size*, infrastructure, top management support	Business competition, vendor support, government policy*
Nilashi et al. [123]	HIS	Relative advantage, complexity*, compatibility*, security concern	Infrastructure, top management support, hospital size, financial resources	*Intensity of competition,* vendor support*
Ahmadi et al. [122]	HIS	Relative advantage*, complexity, compatibility*, security concern*	Infrastructure, top management support, hospital size*, financial resources	Vendor support*

Considering the studies shown in Table 2, applying TOE framework in several researches on health information systems adoption, demonstrates the possibility of fitting TOE framework into the context of HIS adoption. These studies are based on circumstances and various needs of the hospital’s organization according to the technology, organization, and environment dimensions. In addition, Table 2 attempts

to show noteworthy prior studies that used TOE framework related to the context of HIS with focusing on the adoption decision process of healthcare organizations. Furthermore, factors related to those dimensions have an important role in facilitating or inhibiting the decision to adopt an innovation in hospital organizations. Nonetheless, dimensional factors are measured in their own way based on different needs and definite components of HIS in each of those studies.

2.4.2 Human-Organization-Technology Fit Model

Research conducted on adoption of health information technology stressed on large number of adoption complications that emanated from lack of fit between technological, human and organizational contexts [122, 69, 97, 33, 22]. Recently, Yusof *et al.* [108] and Yusof *et al.* [104] identified the important dimensions through conducting a rigorous evaluation of health information system, that intensively affect the system adoption. By making a critical assessment of the results obtained from the current IS evaluation research and health information system, they developed a new model based on human, organization and technology dimensions. Fig. 2 shows the HOT-fit model. The dimensions addressed technological, human and organizational issues.

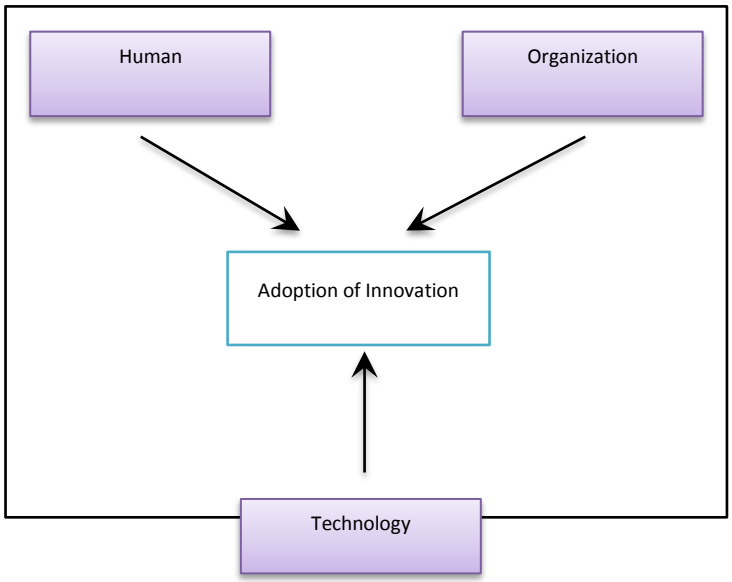

Fig. 2. HOT-fit Model [104]

Yusof *et al. [104]* suggest that HOT-fit model is flexible that can be employed to analyze and assess different phases of system development life cycle, different contexts and purposes. Their proposed health information system evaluation framework incorporates comprehensive dimensions and measures. The researchers emphasize that there is a positive relationship between the possibility of health information system and the degree in which organization, human and technology match with one another.

According to Yusof *et al.* [104], practitioners and researchers can take advantage of the HOT-fit model to conduct rigorous evaluation research on IS or IT applications adoption in the context of healthcare centers. The emphasis of the majority of

available research on the HIS is clinical processes or technical issues that leave the reason of success or failure of HIS in certain context and with certain user [17]. Yusof *et al.* [103] and Yusof *et al.* [104] provided a comprehensive, specific evaluation factors, dimensions and measures (HOT-fit model) which can be suggested to be applicable of different contexts regarding adoption of the HIS in its evaluation [60, 69, 110, 122].
Kilsdonk *et al.* [132] noted that adopting healthcare information systems in hospital setting is the most important emphasis of HOT-fit model. This research focused to examine the effect of human resources in the adoption of HIS. Ahmadi et al. [122] provided evidences about the importance of HOT-fit to lead the successful adoption of HIS in the context of Malaysia. In line with this, Yusof *et al. [103]* classified human into user involvement, clarity of system purpose, user skills, user roles, user perception and user training. These factors pertaining to the human context, which their effects have been measured on the organizational adoption of health information systems. According to the aforementioned discussions, HOT-fit model may be entirely a suitable model in this study applied to assess and determine the relevant factors affecting the decision process of HIS adoption within public hospitals regarding a developing country, Iran.

2.5 Main Drivers and Barriers of the HIS Adoption

The research model developed in this study requires to be comprehensive to investigate drivers and barriers of HIS adoption in the hospital context. The literature attempted to establish the research model by identifying variables that are crucial. The studies regarding the technology adoption have attempted to identify major dimensions and variables that have an important role in determining the adoption behavior [123, 60, 102, 69, 111, 57]. Nevertheless, it is not feasible to incorporate all possible variables in one research model. Hence, to produce empirical results with high validity and reliability, researchers usually choose and examine a few important variables in one research model. On the basis of this study and the results achieved from a review of relevant research, the comprehensive dimensions and variables are included in this study to investigate the adoption of IS in healthcare domain particularly hospitals. Table 3 lists dimensions and variables extracted from the TOE framework and HOT-fit model based on the prior innovation and HIS empirical studies regarding the adoption context.

Table 3. Summary of variables results by theories/models with respect to HIS adoption

Author(s)	Hospital Innovation/ Technology Studied	Theories/Models Used	Dimensions/Variables									
			Technology					**Organization**			**Human**	
			Relative Advantage	Compatibility	Complexity**	Security Concern**	IS Infrastructure	Vendor Support	Top Management Support	Financial Resources	Competence of IS Staff	Employees' IS Knowledge
Yang et al. [102]	Vital signs monitoring System	TOE	√*	√*	√*			√	√*	√*		
Hsiao et al. [39]	MNIS	TOE		√				√*	√		√*	
Lin et al. [61]	HL7	TOE		√*	√*	√		√	√*			√*
Chang et al. [10]	E-signature	TOE			√	√	√*	√*		√*		
Chang et al. *[11]*	PACS	TOE	√*	√					√*			
Lee and Shim [57]	Hospital RFID	TOE (need pull & technology push)	√*									
Lian et al. *[60]*	Health cloud computing	TOE+HOT-fit	√	√*	√	√*			√*	√*		

* Empirical significant factors
** Barriers to HIS adoption

Table 3. Summary of variables results by theories/models with respect to HIS adoption (continued)

Author(s)	Hospital Innovation/ Technology Studied	Theories/Models Used	Dimensions/Variables										
			Technology					**Organization**			**Human**		
			Relative Advantage	Compatibility	Complexity**	Security Concern**	IS Infrastructure	Vendor Support	Top Management Support	Financial Resources	Competence of IS Staff	Employees' IS Knowledge	
Li et al. *[59]*	Mobile nursing technology	TOE		√					√				
Hung et al. *[44]*	Hospital CRM system	TOE	√*		√		√*	√*				√*	
Liu [62]	Telecare	TOE	√	√				√*	√				
Marques et al. *[69]*	Medical Records System	TOE+HOT-fit						√			√*		
Ahmadi et al. [109]	THIS	TOE	√	√	√	√	√	√*	√*	√			
Ahmadi et al. [110]	HIS	TOE+HOT-fit	√*	√	√		√	√	√	√	√		
Ahmadi et al. [122]	HIS	TOE+HOT-fit	√*	√*	√	√*	√	√*	√	√	√	√	
Alam et al. [142]	Human Resource Information System (HRIS)	TOE+HOT-fit	√	√	√		√*		√*			√*	
Alharbi et al. [144]	Cloud based hospital information system	TOE+HOT-fit	√	√	√	√			√	√	√	√	

* Empirical significant factors

****** Barriers to HIS adoption

able 3 shows the prior empirical studies pertaining to the HIS context that used the TOE and HOT-fit theoretical model to assess the effects of respective variables on HIS adoption. Hence, possible articles related to HIS have been retrieved and read. Variables which can have a strong effect on the process of adoption of HIS pertaining to each dimension of technology, organization, and human were sought and depicted. Thus, it can be said that HIS adoption has been mostly affected by those dimensional factors. However, the measures were different for each study using the generic theories of organizational innovation adoption. Thus, in the light of theoretical examination of the empirical studies of HIS in different studies of adoption, the researcher borrows those most frequent dimensional factors from the established adoption theoretical-studies and uses them in the process of developing the conceptual model for HIS adoption in Iranian context. It is believed that the three dimensions including technology, organization, and human are well suited in this research for studying the HIS adoption by public hospitals in Iran.

3. Materials and Methods

To perform this study, two public hospitals of Iran in Bandar Abbas and Qeshm cities were selected. These hospitals implemented a few components of HIS. This research was performed in two rounds. During the first round, different reliable databases with the thesaurus terms "hospital information system", "adoption", "implementation", "TOE framework", and "HOT-fit model" were searched. These databases include MEDLINE, IEEE, Emerald, Elsevier, and PubMed. We limited the search year from 2000 to 2017. In the second round and after identifying the potential dimensional factors that affect hospitals adoption decision of HIS in public hospitals, we evaluate the identified dimensional factors using Dematel and ANP techniques to find the significant result. We used convenient sampling and the main selection criteria were based on the feasibility of data gathering from hospitals staffs and their potential to share the required information. The data collected from the 19 of February till 15 of March.

4. Proposing an Integrated Hospital Information System Adoption Model

The findings of the existing related literature based on TOE and HOT-fit theoretical model with an attempt on reflection to the prior hospital innovation adoption studies provided a great insight into the HIS adoption and served as an important function by informing the development of an integrated HIS adoption model. The literature about health and innovation adoption was explored further to investigate the roles of these findings in determining the behavior of innovation adoption. In addition, those dimensional factors were found based on the existing literature review of Hospital innovation adoption in the hospital context of Iran and other countries. Therefore, this would help researcher to develop initial model for HIS adoption. The next section presents the initial integrated theoretical model for HIS adoption. Fig. 3 illustrates an initial integrated theoretical model for adoption of HIS.

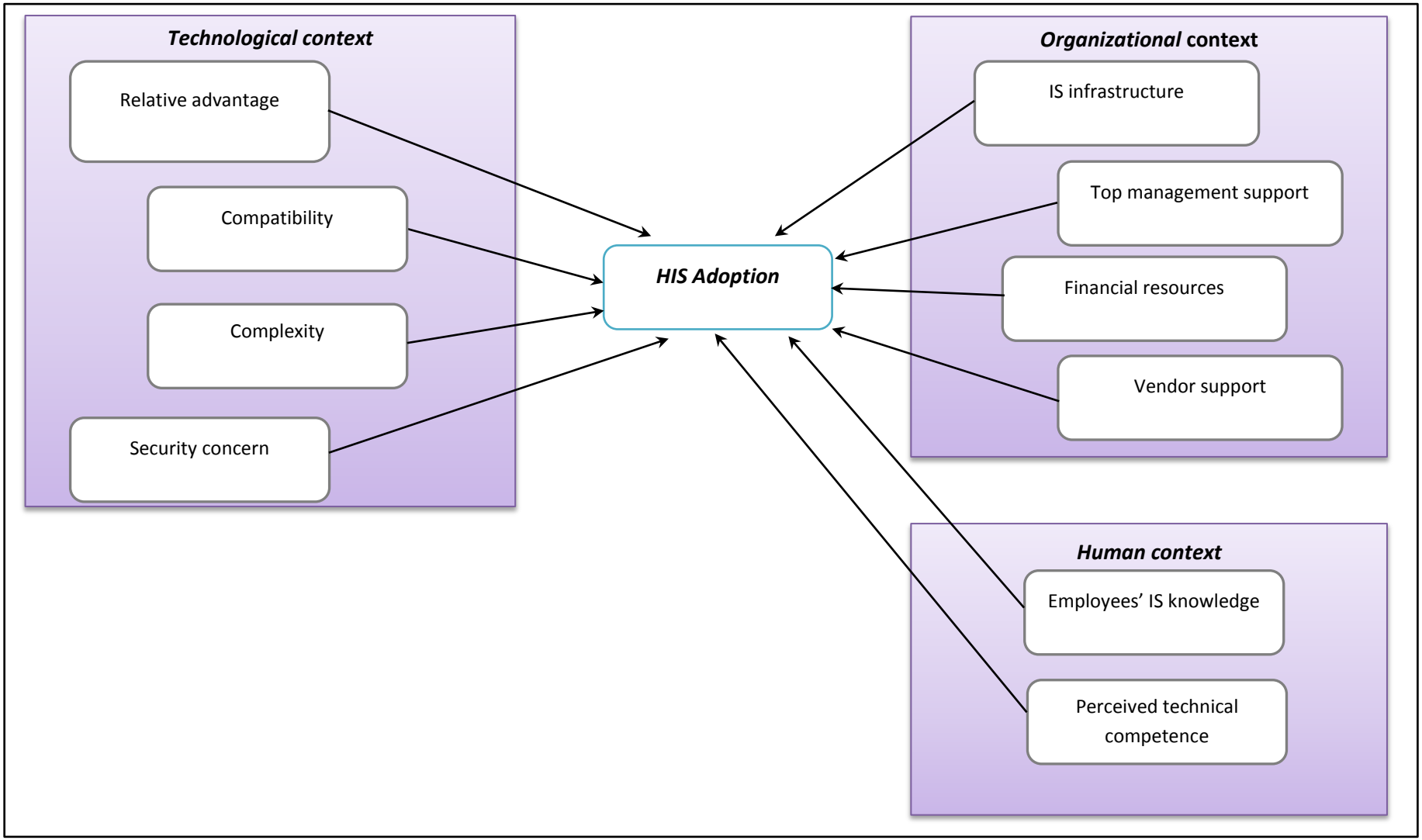

Fig. 3. The initial integrated theoretical model and hypotheses

4.1 An Initial Integrated Theoretical Model for HIS Adoption

Fig. 3 illustrates an initial integrated theoretical model for adoption of HIS. The initial model is proposed through enfolding literature within a hospital's context. Moreover, the model is founded by two theories, including TOE framework and HOT-fit model. In this model, the factors of and the barriers to HIS adoption are categorized into three dimensions, which are Technology, Organization, and Human. As shown in Fig. 3, Relative Advantage, Compatibility, Complexity and Security Concern are categorized as the Technological Dimension. IS Infrastructure, Top Management Support, Financial Resources and Vendor Support are categorized as the Organizational Dimension. Finally, Perceived Technical Competence of IS Staff and Employees' IS Knowledge are grouped as the Human Dimension to accelerate the adoption of HIS. However, the researcher found that the barriers to HIS adoption are mainly related to technological dimension, which are the complexity and security concern.

4.1.1 Technological Dimension

Technological dimension describes the innovation characteristics that have been used by various studies in prior IS innovation affecting the adoption [81]. Four innovation characteristics have been identified in the context of prior HIS studies including relative advantage, compatibility, complexity and security concern. As discussed earlier, DOI suggests five variables regarding the innovation features, which are composed of relative advantage, compatibility, complexity, observability, and trailability. Nevertheless, in an attempt by reviewing the IS innovation studies and supported by prior HIS adoption studies, it is identified only relative advantage, compatibility, and complexity to be significant and frequent that motivated the hospital organizations to adopt the HIS. In addition to these HIS characteristics, this study adds another factor as security concern. In prior HIS studies, security concern has been considered by various researchers and recognized as a significant barrier that prevents hospital organization from the adoption of HIS [122, 60, 65, 61, 10, 85].

4.1.1.1 Relative Advantage of HIS

Hung *et al.* [44] in their HIS study discussed the factor relative advantage and find out its positive result noting that more advantages realized to be achieved from adopting HIS, the more enthusiasm the hospital would have in HIS adoption. In addition, Lin *et al.* [61] studied Health Level Seven (HL7) innovation adoption among the Taiwanese hospitals and found out that communication interfaces would be simplified by using HL7 and the interoperability among heterogeneous healthcare application is allowed. According to Chang *et al.* [11] and Ahmadi et al. [122], operating costs of the hospitals nowadays become a big concern due to increasing competition among hospitals. IDT suggests that an organization's propensity to adopt an innovation is positively affected by relative advantage of an innovation.
Chang *et al.* [11] found out that HIS improves the quality of patient care and it can increase the productivity of the hospital staff. Additionally, study conducted by Hsiao *et al.* [39] regarding MNIS for nursing process in hospital context asserted that disseminating the more timely information and record of medical lead to inspire decision-making support and accordingly improve the quality of care; thus MNIS can change the field, drastically [39]. Hence, prior researches associated with HIS adoption indicated that, the power of relative advantage positively drives the hospital's decision to adopt the HIS.

4.1.1.2 Compatibility of HIS

According to Rogers [81], compatibility refers to "the degree to which an innovation is perceived as consistent with the values, experience and needs of potential units of adoption." Innovation Diffusion Theory (IDT) proposes that higher compatibility of an innovation with values, experiences, and needs of an organization will boost the adoption of an innovation. In addition, Thong [93] emphasized that one of the important factor regarding the IS innovation adoption in the organizational context is compatibility. This can be due to the fact that with a high level of compatibility, small adjustments and changes are required to be applied by the organization, which indicates scant resistance to adoption [93]. Nilashi et al. [123] believed that compatibility is a crucial factor affecting the decision of an organization to adopt HIS adoption of Malaysian public hospitals.

In a study conducted by Ahmadian *et al.* [125] regarding the implementation of HIS innovation in two academic and non-academic hospital's context of Iran, most respondents expressed the compatibility of HIS was low which related to system characteristics of the system task. The authors described this as a major barrier in HIS system implementation. Furthermore, past experience of IS staff considered important in adopting HIS and for evaluating IS as an investment. As a result, one of the important factors in the technical dimension is the level of system compatibility. To being consistent with results of former IS innovation researches and more emphasized by prior HIS adoption studies, perceived high level of compatibility positively has a significant effect on the innovation adoption process.

4.1.1.3 Complexity of HIS

According to Rogers [81] complexity refers to "the degree to which an innovation is perceived as relatively difficult to understand and use." Some organizations may perceive an innovation as complex due to the shortage of associated skill and knowledge, instead not complex by some organizations which possess the required skill and knowledge. Hospitals as the main environment of public healthcare sector has more complex system and workflows compared to other healthcare providers [60, 46]. Jahanbakhsh et al. [121] emphasized that HIS importance becomes clear when the great complexity of health system and the huge number of interventions that each patient faces, the high errors in healthcare organizations. Nowadays, the recent environment of medical is involving with its IT base leading to technological complexity and managing more patients with lesser resources, and hence, facing medical practitioners with higher demands [36]. In many IS innovations, it is emphasized that the perceived complexity of an innovation causes resistance due to the skills and knowledge shortage and hence, has been a key consideration in adopting decision process [9, 93, 35]. Based on studies that applied TOE to examine the adoption process of an innovation, complexity is negatively associated with the adoption of IS innovation [110].

4.1.1.4 HIS Security Concern

In the healthcare environment, one of the concern in adopting ICT is data security [95, 98]. According to Lin *et al.* [61], medical behavior is closely linked to a patient's personal life or privacy and safety, therefore, information security and accuracy should be taken into consideration by the healthcare provider, attempting to punish any possible errors. However, the evidence depicted that computer systems in numerous organizations are subject to repeated and persistent abuse [56, 33].

Study conducted by Khoumbati *et al.* [51] examined the factors affecting Enterprise Application Integration (EAI) in the context of healthcare. They state that security and confidentially are the issues that require immediate consideration. According to case study conducted by the Sulaiman [87] in the public hospitals of Malaysia, the level of security concern has been reported high in HIS due to the fear of breach of patient's privacy during data transaction. In addition, Luxton *et al.* [65] found out that one of the most important challenge in the context of a distribute environment is security problem. This issue may be more relevant to the case of hospitals where the healthcare data needs more secured environment for storage and retrieval. Furthermore, privacy issues are also a major concern in the healthcare industry [60, 8].

Security concern has been demonstrated in prior studies of HIS that significantly affect the decision to adopt HIS. Jahanbakhsh et al. [121] investigated the factors affecting the successful utilization of e-health technology with regard to HIS, in several Iranian public hospitals. They found that mechanisms of IT security protection are lacked and also there are no familiarity of staffs with standards of IT security such as ISO/IEC 27001. Therefore, in the present study, this element is included to be investigated. Furthermore, in other studies of technological innovation in the healthcare, security concern has been one of the critical factors that inhibits the process of adoption decision in the healthcare context [60, 51, 14]. Thus, it is crucial in the current study to investigate the importance of security concern regarding HIS in terms of adoption within public hospitals.

4.1.2 Organizational Dimension

Characteristics of an organization can affect the technological innovation adoption of an organization [96, 60]. According to TOE [96], three dimensions that affect the adoption of technological innovation with regard to organizational dimension are suggested. Based on an attempt reviewing prior studies of IS and also HIS in our study, four characteristics recognized as the most frequent important features of organizational dimension to positively influence the adoption process. These features are IS infrastructure, top management support, vendor support, and financial resources. Hence, it can be stated that organizational dimensional factors of a hospital affect the adoption of HIS.

4.1.2.1 IS Infrastructure

According to IS innovation adoption literature as was reviewed and described, IS infrastructure was found to be one of the most frequent factors that affects the adoption process. IS innovation literature strongly suggesting that a firm's technological strength has a crucial role in adopting any kinds of technological innovation [67, 80]. IS infrastructure includes tangible resources, namely infrastructure components such as hardware and software. Infrastructure in many of the developing countries faced the limitation of sufficient and necessary infrastructure such as skilled human resources, hardware, and software to implement healthcare systems [125]. Ahmadian et al. [125] believed that in Iran a proper planning should be applied which can help growing the available resources productivity.

Moreover, in developing countries, public hospitals encountered some issues regarding the IS infrastructure [68]. According to Zhu *et al.* [108], regarding the technical context, there is less developed IS infrastructure within organizations in developing countries. As an example, in Pakistan, hospital sector faces barrier of IS infrastructure which find difficulty in obtaining a suitable software and hardware [68]. Additionally, Ismail *et al. [46]* surveyed several tertiary

public hospitals in Malaysia to identify the issues and challenges in the development of HIS. They found that infrastructure issue should be considered as well within the country. Accordingly, it is imperative that IS infrastructure be investigated in the context of Iranian public hospitals to see its effect on the adoption of HIS technology.

4.1.2.2 Top Management Support

Jeyaraj *et al. [47]* in their review of IS adoption literature noted that IS innovation adoption in organization is significantly predicted by top management support. On an attempt to review the prior empirical studies of health innovation adoption of Ahmadi et al. [110], it was indicated that the frequent role of top manager's support has a positive effect to change the attitude of the organization towards adopting the IS innovation. In addition to that, Thong and Yap [94] asserted that the attitude of top managers influences the innovative technology adoption, particularly when they understood advantages and disadvantages of IT and knowledge or experiences in IT.

In the healthcare domain and the context of HIS, top management support found to be crucial for the introduction of PACS innovation [11]. Furthermore, Chang *et al. [11]* emphasized that top manager's support critically affects the decision for the PACS adoption. Moreover, in the context of healthcare environment, Yang and Lim [102] and Ahmadi et al. [110] stated the importance of top management in providing the adequate resources (financial and other sources) for adopting vital sign monitoring system and HIS, respectively. To adopt and implement HIS, hospital organizations may need some resources. Additionally, it is important to have a sufficient knowledge or experience regarding the HIS technology. Therefore, hospital organizations with top management support for HIS technology are highly possible to have more willingness in adopting it.

4.1.2.3 Financial Resources

Financial resources have been a popular antecedent to IS diffusion [107, 45]. According to various researchers, sustainable funding (including funding plans) available for implementing and continuing (after pilot stage) an innovation is one of the strongest predictors for successful adoption and implementation [6].

Regarding the context of technology innovation adoption in healthcare, previous studies strengthen that calculating return on investment, high costs, and sufficient financial resources are important challenges and contributions to adopting HIS technology [10, 88]. According to the study conducted by Sulaiman [87] within public hospitals in Malaysia, financial resources realized to be the main reason of why the assimilation of HIS is slow and unsuccessful. In this respect, adequate fund supported by adequate monetary management has been emphasized strongly to be associated with the HIS adoption and implementation. In addition, previous researches strengthen the importance of financial resources in the context of IS adoption. As an instance, MacKay *et al. [66]* determined that financial resources positively affect the decision of organizations in establishing a website. Another example is Chang *et al. [10]* who noted that e-signature adoption is highly related to the financial resources available in the hospital's organizations. Therefore, hospitals need to ensure financial resources in terms of IT budget in order to facilitate HIS implementation.

4.1.2.4 Vendor Support

By taking the perspective of TOE framework, it has been empirically supported the imperative role of vendor support in hospital's adoption of HIS [123, 88, 46, 62, 39, 10]. For instance, Sulaiman and Wickramasinghe [88] and Ismail *et al. [46]* pointed out the apparent issue of vendor support in the Malaysian public hospitals. Jahanbakhsh et al. [121] conduct a study to identify the major barriers regarding the HIS utilization. The authors found that when the new HIS system is ordered by hospital, a vendor is assigned do the network-based application to integrate in different hospital areas such as wards, pharmacy, reception, financial and departments. In addition, they found that the vendors are far from them and updating their system on the basis of their needs takes some times, hence HIS implementation has been unsuccessful [121].

Chang *et al. [10]* noted that in Taiwan, healthcare technology assisted by vendors usually provides solutions from on-site training to link the innovative technology to the IS buyers. Hence, perceived system complexity by all hospitals are low. Barlow *et al.* [128] found that to achieve a successful project plan, assigning a skilled team to fulfil the plan will undoubtedly be the crucial factors at the final stage of telecare adoption. Nilashi et al. [123] and Ahmadi et al. [122] strongly suggest that Malaysian public hospitals should not overlook the importance of vendor support if they want to successfully implement HIS. Therefore, vendor support has been frequently suggested to be a critical factor for the adopting unit to successfully continue the adoption of Hospital technology in hospitals.

4.1.3 Human Dimension

According to the HOT-fit model, human factor is central to the evaluation of health information system adoption and development [103, 104]. Literature on HIS shows that the studies neglect this important concept in explaining the role of human context in behavior of hospital setting towards HIS adoption [60, 122]. According to Marques *et al. [69]*, within the context of hospital setting, the factors involved in the human context should be taken into consideration when adopting and implementing any technological innovations. Hence, taken from HOT-fit model, this study embarks on the analysis of human components in understanding the decision to adopt HIS in the hospital industry. Hence, it can be stated that factors of human dimension within hospital affects the adoption of HIS.

4.1.3.1 Perceived Technical Competence

Perceived technical competence refers to the capability of IS employees [60]. Ross *et al.* [140] believe that IS staffs are the core feature of a valuable human asset that frequently lead the solution to the business problems and addresses business opportunities through IT. In the context of innovation and within the healthcare industry, IS employee's skill has been identified that affects the organizational adoption of IS innovation [60, 4, 52, 38, 106, 93].

According to prior studies of HIS, staffs' technological capabilities has a crucial role when a hospital is adopting an innovative IS [61, 62]. To ensure that business problems will be solved and able to attain business opportunities through the usage of IT, possessing powerful IS skills and competencies are vital [140]. According to Lian *et al. [60]*, if the IS staffs have sufficient knowledge and the needed skills to adopt the new IT, that hospital will undoubtedly have more certainty throughout the process [60]. In addition, Moghadam and Fayaz-bakhsh [126] conducted a study of interview in year 2009 to explore the most important issue of HIS use among the Iranian public hospitals. They strongly believed that if the hospitals want to receive an ultimate

goal of successfully implementing HIS, system training and obtaining the feedback from the healthcare staff are vital.
To adopt HIS, the organization of a hospital requires a capable IS department consists of a group of IS staff who have technical competence. This comprises of sufficient IT knowledge and capabilities to run and support the functions of HIS and therefore adopting the HIS. Thus, it is highly likely that hospitals with strong IS staff manpower for HIS are certain to adopt this technology. Hence, the present study undertakes the human dimensional characteristics to examine the HIS adoption in hospital context.

4.1.3.2 Employees' IS Knowledge

According to Hung et al. [44], many organizations delay their innovation adoption because of the skill and technical knowledge shortage that are needed in the process of development. Therefore, those organizations have to wait until sufficient technical expertise can be available. Thus, if organizations possess staffs with more knowledge of IS, then they will have more tendency to adopt IS [44]. As Ettlie [28] indicates, staffs have to be knowledgeable about IS innovation in order to use more innovative IS. Furthermore, Lin *et al.* [61] state that staff's IS capability is a factor that frequently has been discussed through previous studies.
Sulaiman [87] found that staff faced some issues about using the HIS technology in the Malaysian public hospitals. These issues comprise of the lack of IS/IT exposure to medical staff and managing human resources including healthcare staff assigned by government. She further emphasized that in the HIS project implementation, the clinicians' buy in process is critical [87]. Sobol *et al. [84]* strengthen that staff's IT knowledge and capability significantly affects the medical computerized system implementation. In the case of investigating the critical factors for the integrated technology as for HL7 adoption, Lin *et al*. [61] found that staffs' IS capabilities would help hospitals more likely to accept the hospital technology. Furthermore, Ahmadian et al. [125] in their analytic-descriptive research understood that users' knowledge about the system has become very crucial to utilize the technology of HIS.

5. Methods

5.1. DEMATEL

Decision-Making Trial and Evaluation Laboratory (DEMATEL) has been an effective technique of Multi-Criteria Decision Making (MCDM) for decision analysis in recent years [135]. This technique is mainly used for discovering the relationships among the factors or complex dependency issues among criteria for a problem under investigation [136]. The effect scale described earlier is used to register the degree of influence. The steps of DEMATEL are described as follows:

Step 1: Subsequent to the accumulation of statistics from the experts, design a $n \times n$ (factors under investigation) answer matrix $X^k = [\ x_{ij}^k\ ]$ with $1 \le k \le H$, where H indicates the number of experts. The experts provide their responses on a scale ranging between 0 and 4 (see Table 4).

$$X = \begin{bmatrix} 0 & x_{12} & \cdots & x_{1n} \\ x_{21} & 0 & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & 0 \end{bmatrix}$$

The response matrices for each of the experts are expressed as $X^1, X^2 \ldots X^H$. Every element of X_k (x^{ij}) is an integer on the effect scale denoting the extent to which factor *i* influences factor *j*. It should be noted that due to the fact that the DEMATEL procedure does not include an assessment of a factor's self-influence, the major diagonals of each answer matrix are fixed as zero.

Table 4. Effect scale.

Value	Meaning
0	No effect
1	Low effect
2	Medium effect
3	High effect
4	Very high effect

Step 2: Generate an average matrix A = [a_{ij}] by computing the average influence level as follows:

$$a_{ij=} \frac{1}{H} \sum_{k=1}^{H} x_{ij}^{k} \quad (1)$$

Matrix A, also known as the initial direct relation matrix, reveals the preliminary direct effects of a factor on other factors. This matrix can also be represented in an influence map.

Step 3: During this stage, the regularized direct relation matrix D is computed from the average matrix A. From this computation, the normalization factor $s = \max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}$ is computed to realize the normalized direct relation matrix D.

$$s = \max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij} \quad (2)$$

$$D = \frac{A}{s} \quad (3)$$

Step 4: With the results derived in the third stage, the direct/indirect or total relation matrix (T) is computed as:

$$\lim_{k \to \infty} D^k = 0 \quad (4)$$

where 0 is the null matrix, and so with I being the identity matrix we have:

$$\lim_{k \to \infty} (I + D + D^2 + \ldots + D^k) = (I - D)^{-1}, \; T = D(I - D)^{-1} \quad (5)$$

Step 5: Calculating r_i and c_i which are direct and indirect effects that factor i and factor j exerts and receives on the other factors.

$$\begin{pmatrix} r_1 \\ \vdots \\ r_n \end{pmatrix} \text{ with } r_i = \sum_{j=1}^{n} t_{ij} \text{ where } \quad (i = 1, 2, ..., n) \tag{6}$$

$$(c_1 \ ... \ c_n) \text{ with } c_j = \sum_{i=1}^{n} t_{ij} \text{ where } (j = 1, 2, ..., n) \tag{7}$$

Step 6: The degree of importance of the factor i in the entire system is calculated as:

$$im_i = (r_i + c_i) = \sum_{j=1}^{n} t_{ij} + \sum_{k=1}^{n} t_{ki} \tag{8}$$

$$ef_i = (r_i - c_i) = \sum_{j=1}^{n} t_{ij} - \sum_{k=1}^{n} t_{ki} \tag{9}$$

The net effect that factor i contributes to the system is expressed as ef_i. To be precise, if ef_i is positive, the factor i is deemed a net cause. On the other hand, if ef_i is negative, the factor i is deemed a net receiver. The results attained through these computations can be portrayed in a directed graph to demonstrate the structural linkage existing between the various influence factors.

5.2 ANP

The ANP is a generalization of the Analytical Hierarchy Process (AHP) to the case in which there exists dependence and feedback among factors in decision making problems. Regarding to the independence problem, Saaty has developed an advanced method named Analytic Network Process (ANP). ANP differs slightly from AHP and offers more flexible methodology for a decision maker. In AHP, elements in lower level of hierarchy are weighted and ranked with respect to the higher level. In ANP, however, the model is not restricted by such a hierarchy. This point is clearly explained by Saaty [137], the founder of AHP as well as ANP. Aiming at solving the decision problems which cannot be structured hierarchically on account of the interaction and dependence of higher-level elements on lower-level elements as well as elements in the same level, a feedback network like structure is proposed. In particular, the supermatrix approach is the generalization of the hierarchy approach. It is difficult for many decision making problems to be formulated in a hierarchical way [138, 137, 139]. The computation of ANP can be divided into two main parts:

1. Construction of the super matrix (a) The decision maker enters for each criteria and alternative a pairwise comparison matrix. (b) The values for the super matrix are obtained by computing the eigenvectors of the pairwise comparison matrix and writing them as column vectors in the super matrix.
2. Computation of the limit matrix from the super matrix (a) Next the super matrix has to be normalized to obtain a column stochastic matrix. (b) Raise the matrix by the power of 3. (c) Repeat the previous two steps until the difference between the matrix from step n-1 and step n are smaller than a predefined value.

Although the ranking and weighting can be generated by other methods, ANP is found to be more appropriate in meeting the needs of this research. Furthermore, it is important to reiterate

that ANP is a developed form of AHP that has an ability to deal with a more complex decision making problem. ANP is employed in this case as it represents the more appropriate methodology for the first step of this research.

6. Empirical Study

In our study, based on the analysis of relevant theories in line with reviewing the previous empirical researches on technology adoption with a direct attention to HIS adoption, the potential inter and intra-organizational factors were identified for the adoption of HIS. This study provides evidence for the applicability of new theoretical model integrated by HOT-fit and TOE framework in the IS and health IS domains to specifically explaining the adoption of HIS by public hospitals in the Iranian context. In other words, this study adopted the TOE as the basis of this research and integrated the human capabilities perspective to its dimensions. In other words, human dimension as a necessary supplement was integrated into the developed model. This research uses this integrated theoretical model to develop the Public Hospitals-Integrated Hospital Information System Adoption Model (Public Hospitals-IHISAM). In comparison to previous models, Public Hospitals-IHISAM emphasizes more on intra-organizational factors rather than inter-organizational factors.

This study developed the conceptual research model (see Fig. ٣) based on the laboratory search of extensive literature review and theoretical background. Accordingly, in this section, we develop a hybrid MCDM model for the process of HIS adoption decision. The proposed MCDM model is comprised of two main stages. An overview of the process of hybrid proposed model using DEMATEL and ANP is shown in Fig. ٤. As can be seen in Fig. 4, in the first step, the DEMATEL method is used to uncover the relationship among the dimensions (main factors) and variables (sub-factors) and to find interdependency and feedback among them. It should be noted that uncovering the relationships using this approach is very important to find the weights of main factors and sub-factors appropriately. Hence, to this step, DEMATEL approach is more suitable to be applied in decision-making as it is more suitable for real-world applications compared to the traditional methods in analyzing the interdependency among the components of a network.

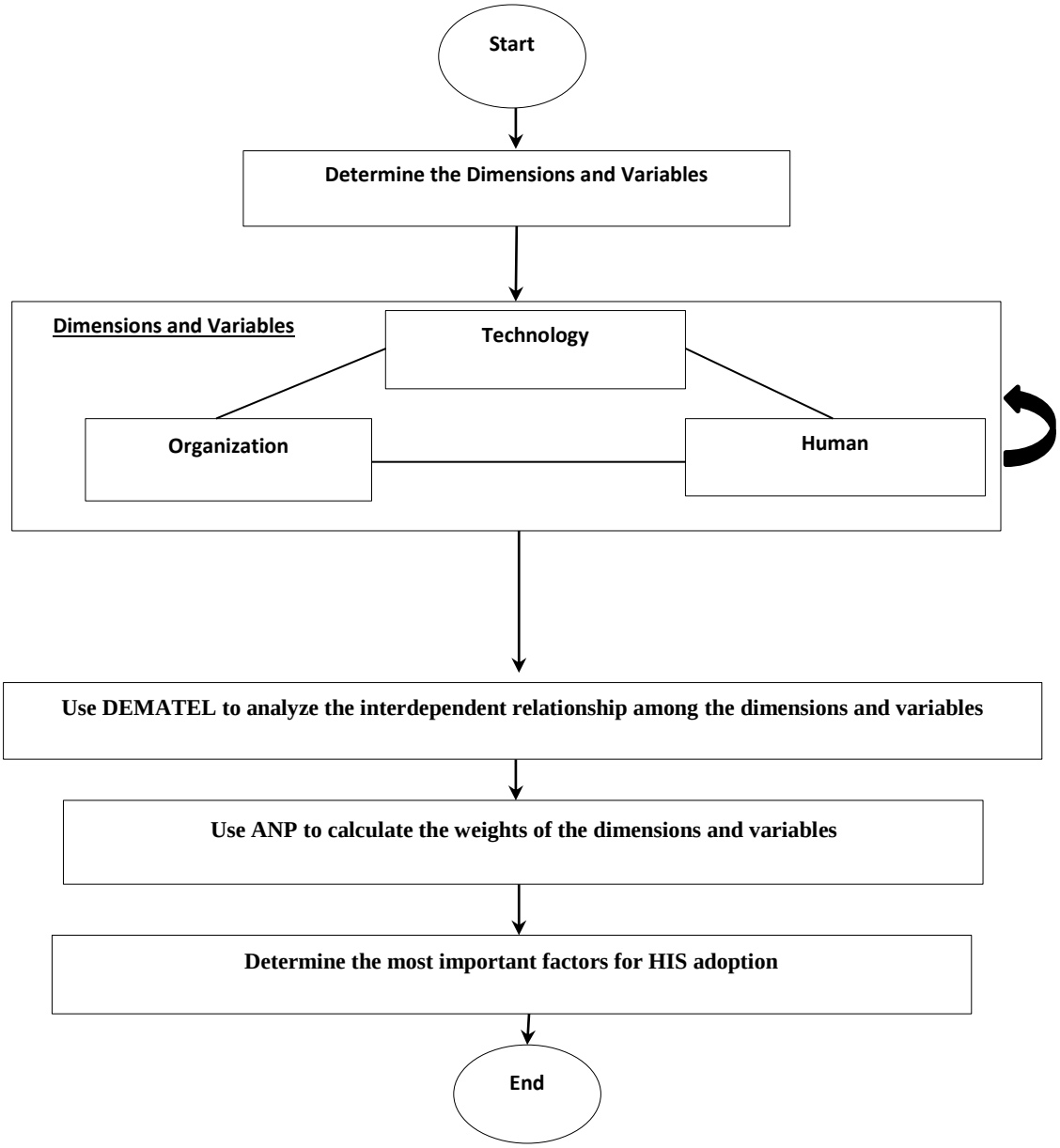

Fig. 4. Research flow for MCDM model

Table ° provides the sample characteristics of the type of respondents for this study. Hence, an indicative sample of characteristics drawn from the profiles of the respondents is presented in Table 5. Participants' responses to items in this part of the questionnaire were examined, using frequency and percentage. The majority of the participants were female (68.18%). The largest group of respondents were in the age of 30 and lower than 30 (61.36%). This shows that respondents were generally from a relatively young population. As for roles of respondents, 18 (40.90%) of the respondents were nurses and most of the respondents (50%) had 6 to 10 years of experience within healthcare industry. This could therefore be seen as a relatively experienced population. The result can demonstrate that the respondents do have some experiences of knowing and using HIS technology.

Table ٥. Sample characteristics

Respondent Characteristics		Frequency	Percentage (%)
Age	30 and lower than 30	27	61.36
	31-34	12	27.27
	35-40	3	6.81
	41-45	2	4.54
	46-50	-	-
	More than 50	-	-
Gender	Male	14	31.81
	Female	30	68.18
Roles of respondents	Chief technology officer	2	4.54
	Chief executive officer	2	4.54
	Chief information officer	1	2.27
	Senior clinician	3	6.81
	Nurse	18	40.90
	Doctors	2	4.54
	Others	16	36.36
Experience in assigned roles	Lower than 1	5	11.36
	1-3	14	31.81
	4-6	10	22.72
	7-9	6	13.63
	More than 10	6	13.63
Experience in healthcare industry	5 and lower than 5	15	34.09
	6-10	22	50
	11-15	7	15.90
	16-20	2	15.90
	21-25	-	4.54

As discussed earlier, in the first step we have applied DEMATEL to find the interdependencies among the dimensions and sub-factors. Table ٦ presents the overall importance for each factor. From Table 6, it can be found that Technological context and Human context are the most important influence factors on HIS adoption. In addition, this table also provide the ranks of sub-factors in each dimension. From the results, Relative advantage followed by Compatibility and Security concern, Top management support followed by Vendor support, and Perceived technical competence are respectively the most important factors in Technological context, Organizational context and Human context. Further, in Table ٧ we can find two groups of factors which are net cause and net receiver factors. From the results, it can be found that the positive values are Net cause factors and negative values are Net receiver factors. The results reveal that Technological context and Human context are Net cause and Organizational context is Net receiver. Moreover, from the results it can be found that Relative advantage, Top management support and Perceived technical competence have the highest net effect on the decision to adopt HIS in each dimension. Furthermore, from the Net receiver group of factor, it can be found that Employees' IS knowledge, Complexity and IS infrastructure have the highest negative effect on the decision to adopt HIS in each dimension.

Table ٦. Degree of importance

Dimensions	Sub-Factors	$im_i = (r_i + c_i)$
Technological context	-	3.7874
	Relative advantage	4.5432
	Compatibility	4.2353
	Security concern	3.0234
	Complexity	1.2343
Organizational context	-	1.3423
	Top management support	4.2433
	Vendor support	3.5432
	Financial resources	2.2847
	IS infrastructure	1.3242
Human context	-	3.3461
	Perceived technical competence	2.5323
	Employees' IS knowledge	1.3413

Table ٧. Net effect

Dimensions	Net Receiver	Net Cause	Sub-Factors	$ef_i = (r_i - c_i)$
Technological context		√	-	1.9256
		√	Relative advantage	0.7852
		√	Compatibility	0.6895
		√	Security concern	0.1639
	√		Complexity	-0.4532
Organizational context	√		-	-0.5642
		√	Top management support	1.3853
		√	Vendor support	0.6438
	√		Financial resources	-0.1245
	√		IS infrastructure	-0.3464
Human context		√	-	0.9321
		√	Perceived technical competence	0.5436
	√		Employees' IS knowledge	-0.3768

In this study, after discovering the interdependency among the dimensions and sub-factors using DEMATEL, the ANP method was applied to obtain the final weights of three dimensions and the sub-factors in each dimension. Based on the ANP model and relationship structure among dimensions and variable, an ANP based survey with pairwise questions was conducted and distributed to the 44 main users and experts who had experience with the HIS of hospitals in Iran. From the 44 surveys conducted in this study, all of them were valid (effective response rate as 100%). In addition, for the ANP model, the 44 respondents which participated in the survey were asked to provide their answers based on a scale of 1–9 to the pairwise questions, such as 'For the "HIS adoption in the Iranian hospitals", how much more important is "Technological factor" to "Organizational factor"?' It should be noted that in Saaty's 9-point scale the 9 point indicates extreme importance and 1 as the equal importance of one component (dimension and variable) over another. After computing the results of their assessments, the Consistency Ratio (CR) values were all acceptable and the eigenvectors were appropriate to enter into the Supermatrix. According to the steps described for ANP, after calculating the unweighted Supermatrix and weighted Supermatrix, the limit Supermatrix were computed which is presented in Table ٨. This matrix presents the weight of each sub-factor in the dimensions. Accordingly, the final weights of dimensions and sub-factors are presented in Table ٩.

Table ٨. The limit Supermatrix.

Supermatrix		Technology (D_1)				Human (D_2)		Organization (D_3)			
		V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}
Technology (D_1)	V_1	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282
	V_2	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198
	V_3	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141
	V_4	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
Human (D_2)	V_5	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145
	V_6	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
Organization (D_3)	V_7	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
	V_8	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
	V_9	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	V_{10}	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026

Table ٩. Model with relative indicator weights

Dimensions	Variable	Sub-Factors	Final Weights
Technological context	D_1	-	0.487
	V_1	Relative advantage	0.282
	V_2	Compatibility	0.198
	V_3	Security concern	0.141
	V_4	Complexity	0.055
Human context	D_2	-	0.389
	V_5	Perceived technical competence	0.145
	V_6	Employees' IS knowledge	0.048
Organizational context	D_3	-	0.124
	V_7	Top management support	0.044
	V_8	Vendor support	0.033
	V_9	Financial resources	0.028
	V_{10}	IS infrastructure	0.026

7. Discussion

The conceptual research model in this study was developed and the two evaluation methods of ANP and DEMATEL was analyzed; additionally, data was collected from 44 professionals and main users in the context of hospital, hence, the significant dimensions and variables affecting the organizational innovation of HIS was identified and confirmed. In this regard, Technology and Human with an influence weight of 0.487 and 0.389, are the most crucial dimensions for assessing the HIS adoption. This result obtained using DEMATEL and ANP analysis techniques. This indicates that major decision-makers of hospitals involving HIS adoption, should not overlook them.

The research findings in this study indicate that relative advantage of HIS has a significant positive relationship with HIS adoption (with an influence weight of 0.282). This finding is also consistent with the study of Ahmadi et al. [122] asserted that HIS brings convenience to healthcare organizations regarding the cost reduction, patient care processes which can expedite the decision-making process, time saving and improve patient care. The meta-analysis study of

Jeyaraj et al. [47] found that relative advantage of innovation is one of the best predictors of innovation adoption in the organizational context. As a result, this study asserts that hospitals require to realize the relative advantage of applying HIS applications or in other words, some expected benefits using the HIS. Hence, it is important that government develop strategies to increase the awareness of the average relative advantage hospitals regarding the diverse benefits of HIS technology.

The research findings in this study indicate that high level of compatibility has a noticeable positive effect on HIS adoption (with an influence weight of 0.198). The study confirms the findings of other studies that high level of HIS compatibility with existing systems is the significant factor influencing hospital's decision of adopting or implementing the HIS [60, 102, 61, 43, 122]. Yang et al. [102] updated TOE to be in line with the health information system environment. The results of their studies support the inclusion of innovation characteristics and in particular compatibility as part of the TOE perspective that can influence the decision to adopt wireless vital signs monitoring system. Adoption diffusion studies also found that an innovation, which is more compatible, attracts faster adoption by the prospective adopters. This may be due to the fact that with a high level of compatibility with HIS or any other innovations, solely, the minimal adjustments and changes is required to be undertaken within hospital organization which implies less resistance to adoption. The government and hospital manager should therefore develop better and more extensive HIS strategies and plans specifically within the average compatibility hospitals context to ensure the integration of new HIS systems within hospitals, leading a hospital to a better future.

The research findings of this study demonstrate that security concern is found to have a significant negative relationship with hospitals to adopt HIS, meaning that higher concern with security will result in lower adoption of HIS by hospitals (with an influence weight of 0.141). The present finding is in accordance with the findings of Lian et al. [60] who explored hospital's adoption of the new technology. Their study concluded that security concern has a greatly negative influence on behavior of hospitals' adoption of innovative technology. Due to the significance of patient data in hospitals, secure environment for storage and retrieval of data is required that hospitals feel safe to use the HIS system. Thus, greater concern about security of data is one of the major issues for every hospital to adopt and migrate to the HIS. Additionally, study by Ahmadi et al. [122] posits that the concern for the data security is one of the major issues for every organization to adopt and migrate to the innovative technology. In other words, the concern of the data security in hospitals is high. Therefore, security concern needs to be identified as one of the crucial factors in HIS adoption. Thus, it is important to develop the strategies in order to ensure the high level of data security regarding the HIS technology, therefore to encourage hospitals to use HIS in their work processes.

In this study, top management support (with an influence weight of 0.044) and vendor support (with an influence weight of 0.033) were observed to have a significant influence on HIS adoption in the hospitals. Sulaiman [87] and Ismail et al. [46] came to the same conclusion. They investigated the hospitals major issue of HIS adoption in a developing country. Ismail et al. [46] through an in-depth interview highlighted that the multiple vendors support in the context of Malaysian public hospitals cause a main challenge for HIS implementation. Furthermore, Jahanbakhsh et al. [121] found that selecting the appropriate vendor that provides the perfect support are essential that lead to succeed the utilization of HIS. Besides, the result of this study is consistent with some previous studies in the domain of healthcare [121, 110, 122] where vendor support found to be significantly affecting the hospital's technology adoption.

This study's result is more supported by the study of Sulaiman [87] that was conducted within a Malaysian public hospital. The author found that being dependent on the international vendor software causes local hospital staff to have insufficient skills and knowledge, thereby causing to increase the cost of overseas vendor support and maintenance. Thus according to the result of this study, more in-house development should be established to reduce cost as well as strengthen local IT skills and experience. It is also vital to the alignment of the selected IT vendor organization goals to the hospital's HIS strategic goals in order to guarantee better quality delivery and support such as training. There is also a requirement to perform frequent evaluation of the selected IT vendor company regarding the IS services in terms of efficiency and effectiveness. Additionally, the transparency has to be assured that will assist to ensure positive values of integrity and honesty in procurement and IT vendor selection process.

"Perceived Technical Competence" is another imperative factor with respect to Human dimension with an influence weight of 0.145, which helps to better evaluate the HIS adoption. IT department support has become very important specifically in the adoption stage. This is to ensure that the technical support is adequate and staff working in the IT department have the enough ability. Additionally, the investigation of HIS adoption in Malaysian public hospitals conducted by Ahmadi et al. [122] stressed the importance of perceived technical competence. By applying the DEMATEL technique in the current study, we have explored the interrelationship between dimensions and variables with the purpose of enhancing each dimension and variable. Results described that Technology dimension (D1) and Human dimension (D2) obtained the most priority for adoption development. Therefore, these two dimensions should be looked carefully by administrators in the healthcare industry and also expand upon since they are the most imperative relative to the other dimensions. Thus, the assessment of important identified dimensions and variables found in our study should be performed by administrators for the HIS implementation decision process.

It can be concluded that the relative importance of dimensions and their 10 variables can differ depends on the confinement of each healthcare industry. Nonetheless, factors such as "Complexity", "IS infrastructure", "Financial Resources", and "Employees' IS knowledge" were not supported as the significant factor in this study which created some insights in the Iranian public hospitals.

7.1 Contribution

The main goal of the present study was to develop a model as an effective lens for a concise and comprehensive understanding of HIS adoption decision in the Iranian public hospitals. In other words, this study provides an insight into the factors and barriers that affect the adoption of HIS and particularly to practice these issues among the Iranian public hospitals. Hence, the integrated theoretical model was developed from the reviewing of relevant extensive literature and empirically tested and validated via a quantitative study in two public hospitals of Bandar Abbas and Qeshm. Thus, this research is expected to contribute towards theory and practice.

There are some major theoretical contributions that have been established in this research. Notwithstanding, there are previous literature about the innovation process, a little information is available concerning the process of innovation adoption in public hospitals. Nevertheless, several researchers recently studied the adoption factors of HIS. Considering HIS as an innovation, most studies applied the generic adoption theories to examine HIS adoption. Most applied theories dealing with innovation adoption are DOI [81] and TOE framework [96]. Hence, the first

theoretical contribution of this study is examining the adoption-factors and barriers in the HIS context by integrating TOE [96] with HOT-fit model [103, 104] to potentially explain the HIS adoption by Iranian public hospitals. This study examined the consistency of HOT-fit as a supplement into the TOE framework and developed a new integrated theoretical model for HIS adoption by Iranian public hospitals. Furthermore, this research adapted, integrated, and extended TOE along with HOT-fit model.

Moreover, there are several studies in all industries that pointing out the importance of the human dimension upon the adoption of IS, where the TOE framework does not have an explicit category "Human". Regarding the literature in HIS, most studies overlooked this concept in explaining the role of human as a strong motivation in behavior of hospital towards HIS. Hence, the present study has an important theoretical implication that the factors, specifically, perceived technical competence of IS staff engaged in the human dimension, crucially need to be considered in further research when adopting and implementing HIS.

As we move further into the 21st century, the use of HIS to provide an integrated care delivery system that provides greater efficiency with easy access of data, ability to improve patient's safety as well as providing better record management and security is unavoidable. In Iran, it is important to clarify the e-Health national projects which is in the same line of the Iranian 5-year national plan assists to reveal the efforts and achievements of the government, and may provide lessons learned within each hospital during HIS utilization. This is exactly in line with the Iranian 5-year national plan to have ISs in the backbone of every initiative concerning the healthcare industry and in particular hospital facilities. However, this plans and projects have not been as progressive as it was intended to be [121, 125, 134]. In addition, prior to this study, there was little understanding in the factors influencing the adoption of HIS by Iranian public hospitals. This study provides an insight in explaining the factors influencing the HIS adoption based on theories and empirical results. With this understanding, practical guidelines can be derived for designing strategies geared towards enhancing the effectiveness and availability of those significant factors. Thus, the results of this study provide numerous beneficial implications for policy makers at Ministry and Healthcare and Medical Education, IT and hospital senior managers as well as researchers in the field of healthcare.

7.2 Practical Implications

The findings obtained in this study have several meaningful implications. First and foremost, the results of this research support Abdullah's [129] view that although there is technology and it probably solve most of the potential healthcare shortcomings in a developing country with its use, the selected technology is not without its people, organizational, and technological issues. For example, quantitative phase of the study reinforced the findings obtained by literature in which relative advantage, compatibility and security concern as three technology dimensional factors proved to be the significant determinants of HIS adoption by Iranian public hospitals. This recognition validates the belief that relative advantage, compatibility and security concern are the critical factors that have significant positive effect, respectively on the behavior of HIS adoption [60, 102, 61, 44, 11, 110, 123]. Therefore, relative advantage was found to be an important factor influencing the adoption of HIS technology. Respondents reported doing so because they were aware of the benefits of this technology. Hence, it has implications for the

importance of user awareness of the benefits of HIS which has a positive effect on the adoption of HIS. In this regard, the government should devise an intervention plan to improve the user awareness through better education and training of the senior hospital management and healthcare staffs. Thus, the HIS can be recognized as an enabler to become an ultimate solution of medical advancement in solving critical issues within Iranian public hospitals.

Secondly, the results of this research support the idea that potential adopters easily accept an innovative technology that has higher compatibility with existing systems, practices, and work experiences. This study has an imperative implication for government and hospital managers to fit the HIS into the current hospital work procedures and needs of the hospital. This means that HIS should be compatible with the respective hospital and its tasks. Moreover, this can be interpreted that there are requirements to increase the HIS compatibility with existing hospital's IT architectures regarding applications, hardware, and software with respect to the average compatibility hospitals. Since HIS is a complex project that integrates various ISs technologies and services, hence, this can inhibit the hospitals' decision to adopt HIS due to resistance to change which is a normal organizational reaction. In addition to that, HIS features that are too advanced for the healthcare personnel, requires intensive training.

In the present study, hospitals perceived security concern as a major barrier in their adoption of HIS. Nevertheless, previous studies found security concern as a major obstacle to the adoption decision of HIS [60]. This can be due to the fact that information security and privacy is a general concern in the healthcare industry. Hence, the reliability of network and information security is necessary to be considered and guaranteed in the healthcare environment and in particular hospital setting [56].

Jahanbakhsh et al. [121] wrote that despite strong physical security within some Iranian public hospitals, there are inadequacy of IT security in the hospital environments. Hence, the plausible explanation for hospitals to concern on the confidentiality and security regarding the adoption of HIS is enforcing the sensitive information to be protected by different hospital stakeholders to comply the requirements according to the aforementioned act. Accordingly, many hospitals worry about adopting the HIS due to the data protection issues. It is concluded that the important hospital stakeholders including hospital managers, top management in IT departments and/or vendors use advanced security features to ensure security and data protection are given utmost priority. Besides, authorities of hospitals should prepare a framework of national IT security, on the basis of ISO/IEC 27000 family standard, with the aim of protecting all data available on healthcare servers. Hence, this can be a suitable mechanism assisting to protect the healthcare data.

With respect to the environmental dimension factors, the present study discovered that top management support and vendor support are significant factors that affect the implementation of HIS within the public hospital context. If the top managers are more knowledgeable about IT, the top managers will be more willing to adopt and accept an innovative technology. This is due to the fact that the HIS adoption is enormous project for a hospital that some hospitals lack the resources to implement HIS effectively. Accordingly, the top managers' support and also enough resources have become vital.

Jahanbakhsh et al. [121] conducted an interview study regarding the HIS utilization in several public hospitals of Iran. Authors found that when vendor and hospital have a weak communicating, users face some limitations and problems. As an instance, when the vendor installs the new HIS, some training workshops are performed. Hence, nurses as the main users get problem with the new HIS, also some resistance occurs. Inside hospitals, the IT department

should give support all the time and days of week to alleviate the issues that emerge. After users satisfied with new HIS, and some effective changes were brought with respect to new system, the HIS will be deployed, accepted and no longer complaints made. Thus, inappropriate management support, technical administration and also avoid accepting changes along with improper selection of vendors are the major barriers to implement HIS in Iranian hospitals. Thus, the Iranian ministry should cautiously explain a clear strategy for vendor selection to offer their HIS according to needs of hospital. Vendors should fully give support to applications they developed as all hospital met supplementary challenges and shortcomings on the vendors' part. Selecting the same vendor for more than one hospital may give a better result in solving those issues.

This study found that the human dimension reflects the importance of IS human resources in developing HIS in the hospitals. Therefore, this study revealed a need to prepare training program to the IS staff be hired for a healthcare IS position [112, 60, 54]. In this regard as was suggested by Sulaiman [87], it is very crucial that "medical professionals with IS/IT technical knowledge should hold a position in the IS/IT department to work hand in hand with IS/IT staff throughout all stages of HIS adoption." This assists in adopting the medical systems that would fulfill the medical practitioner's needs and work processes by providing sufficient knowledge to both areas of IS and the medical field. Therefore, IS capability should be carefully assessed by a hospital before a decision to adopt HIS technology is made.

Hence, government agency and in particular Iranian ministry, and hospital administrators may find the results of this study and prepare their strategy and policy accordingly directed at fostering the uptake of HIS. As a practical implication, governments, hospital managers, and other top management teams need to try to adapt the findings of this study for developing and implementing efficient policy. In other words, the model developed in this study can be used as a guideline for assessing and evaluating the factors that will assist in their decision-making and in anticipating the possible influences that will lead to improvements in the process of system implementation. Thus, the study may provide a greater understanding of successful HIS adoption and may contribute to identifying problems before the HIS is implemented. Eventually, it is noteworthy to mention that obtained results, better explaining the potential factors that impact the adoption of HIS in public hospitals.

8. Future Work

On the bases of scope and limitations of this study, there are some opportunities for further research that can be carried out. This study has been conducted in non-teaching hospitals. It is recommended that future research extends the scope of the current study by including a combination of teaching and non-teaching hospitals. The inclusion of teaching would provide an opportunity to understand whether the findings of this study are limited to responses in public teaching hospitals.

Studies of future can do investigation of the HIS adoption by performing survey or interview in HIS adopters and non-adopters context to realize the factors in diverse perspectives regarding the HIS adoption. In addition, it is offered to evaluate and distinguish the different influence of those factors between adopters and non-adopters. By doing so, more generalization of the findings is obtained.

Since the healthcare industry is a much institutionalized environment, it is relatively crucial to scrutinize the effects of institutional pressures on hospital adoption of IS innovation.

Nevertheless, as of now, few studies study has sought the influence of institutional pressures on the process of HIS adoption by using or applying the institutional theory especially in the organizational context. Hence, this can be a potential area to be focused in future to obtain a better understanding the HIS adoption in public healthcare.

9. Conclusion

HIS has a growing importance in hospitals management in the Iranian public health systems. During the performance of this study, a few studies have paid attention in a comprehensive manner to implementation of the HIS, which may put a negative effect on Iranian strategic plan of IT decisions in hospitals environment. Therefore, the crucial dimensions and variables in our study have been identified which can lead to achieve and determine the HIS innovation adoption. TOE framework known as a generic theory of technology diffusion was mainly applied in our study to achieve a better understanding the adoption of technological innovation specifically HIS systems. Additionally, through focusing on HOT-fit model which is related to the context of health information system and integrating it with the TOE framework, this study develops a new and suitable model by covering significant factors which were excluded in former studies to facilitate better the HIS adoption process that to be fulfilled by decision makers and government within public hospitals of Iran. This developed model allows the administrators and managers to assess the identified important factors in better improving the HIS adoption.
The current study used two approaches of hybrid MCDM model including ANP and DEMATEL to make a contribution in the health IS literature. Besides, the interdependencies among dimensions and their contributing variables were assessed towards the success of adoption decision process of HIS innovation. Therefore, from the professionals' and users' viewpoint it was found that "Perceived Technical Competence" is the most crucial factor in the Human dimension. On the other hand, with respect to Technology dimension, the potential respondents believe that the "Relative Advantage", "Compatibility" and "Security Concern" was significant in relation to the other factors. Moreover, in the dimension of organization, "Vendor Support" and "Top Management Support" was understood more powerful than others. ANP survey results explained that the professionals and HIS users emphasized that managers should carefully adapt these factors in hospitals in which the HIS adoption is connected to more attention of these factors. Furthermore, we revealed that the respondents of this study voted more for Technology and Human, as there are a substantial weight of these two dimensions compared to another dimension. Thus, the findings obtained in this study provides guidance to the top management in hospital administration level in HIS field in choosing the suitable way for adoption of HIS, preparing effective mitigation strategies, and contingency plans before HIS implementation and assisting hospital parties to grasp their strategic goals with increased efficiency. In the last part, it is hoped that the present study injected a thorough knowledge regarding the theoretical aspects of HIS technology in the public hospitals as well as gave the future direction for prospective researchers to investigate the HIS adoption.