

How the health information systems can overcome the challenges of migrating to the cloud? A framework based on a mix method approach

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Article Info

Article type:
Research

Article History:

Received: 2021-11-28

Accepted: 2022-01-24

Published: 2022-02-25

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Keywords:

Cloud Computing

Migration

Framework

Health

Health Information System

ABSTRACT

Introduction: Problems facing the health information systems and the potential of cloud computing make the use of this technology as a priority for healthcare organizations to migrate to the cloud. The purpose of the present study is to introduce a migration framework for health information systems to the cloud.

Material and Methods: This study is a Mix method research that was performed in the first stage to identify the relevant factors of a qualitative study until the initial design of the resulting framework was obtained and, in the second phase using the two-stage quantitative Delphi method the framework was evaluated.

Results: The overall component of the proposed framework, which had 149 components consists of four layers of governmental, executive, organizational and technical three major groups of stakeholders in government, the service providers (CSPs) and the service consumers (CSCs).

Conclusion: Cloud computing is a new issue in the health, and the cloud migration process is one of the cost-effective solutions for managing health information systems. Due to the lack of knowledge of health executives on cloud computing, they may not be able to make appropriate decisions on doing the migration. Thus, having a comprehensive framework in addition to enhancing the knowledge decision makers will help them make better decisions while at the same time planning a roadmap for successful migration.

Cite this paper as:

Sadoughi F, El-Gazzar RF, Erfannia L, Sheikhtaheri A. How the health information systems can overcome the challenges of migrating to the cloud? A framework based on a mix method approach. *Front Health Inform.* 2022; 11: 107. DOI: [10.30699/fhi.v11i1.342](https://doi.org/10.30699/fhi.v11i1.342)

INTRODUCTION

Cloud computing as one of the new technological advances has brought a lot of benefits to the information systems audience and has created a good platform for integrating resources [1]; also has had many impacts in various areas, with it being introduced as the fifth-largest industry after water, gas, electricity and telephony [2] due to fewer obstacles in this context than other infrastructures, the organization will be more capable of creative activities as well as upgrading and upgrading its IT

systems [3]. This made several healthcare organizations migrate their current HISs to the cloud. However, challenges such as the sensitivity of health data and the concerns of health organizations about the security and confidentiality of health data in the cloud mandates the need for a comprehensive and clear cloud adoption strategy [3, 4]. To the best of our knowledge, no comprehensive studies have stakeholders. Thus, cloud computing is new in the healthcare domain and a mixed methods research has the potential to contribute to developing innovative solutions to important and complex

problems [5].

The use of information technology (IT) in the field of health has become a necessity in many countries, and has led to a huge evolution in health service provision [6-8]. HISs and electronic health records (EHRs) are being implemented in Iran and given a high priority for the future development of the country in the field of e-health. Previous research indicates that cost constraints are among the most important challenges in the migration of EHRs in Iran, in addition to technical and organizational [9, 10]. Furthermore, isolated and disaggregated hospital information systems are among the major problems that make communication extremely difficult [11, 12]. The lack of sufficient hardware or outdated ones can cause further problems [9, 10, 12]. Cloud computing appears to have the potential to reduce organizational and operational costs, enable transferring technical management of information systems to CSPs that are certainly specialized [4, 13, 14].

The study of cloud computing in the field of health has been technologically devoted too much research [15] but less from an organizational point of view [16]. In general, related studies can be categorized into three categories: the first one examining factors affecting the cloud migration in health [17-20]; the second the studies addressing migration from a general perspective [6, 21-26]; and third category that focus exclusively on migration to cloud in healthcare [27]. Reviewing the literature required a comprehensive study that encompassed all aspects of health in the cloud migration which miss in previous researches [17-27]:

1. Lack of health migration frameworks addressing specific issues in this area: Studies dealing with health issues were only generally discussed and specific details of this area were not considered.
2. Non-stakeholder considerations: Frameworks that have generally addressed the issue of immigration and that various stakeholders have overlooked this area.
3. Low number of studies providing qualitative or synthetic frameworks: conducting qualitative and mix method studies provides a more comprehensive understanding of the issue [20]. While it is important to learn from the available cloud literature, qualitative scientific methods are important in conducting research [28]. Therefore, a framework that can be used with more scientific approaches, seems to be necessary. The purpose of this study was to develop a migration framework for HISs on the cloud in Iran. Our research question is: How the health information systems can overcome the challenges of migrating to the cloud?

MATERIAL AND METHODS

The present study is a Mix method study that has been carried out by exploratory sequential design. In this way the researcher started with qualitative data and then collected quantitative information. The purpose of these schemes is to collect qualitative data to discover a phenomenon and then collect quantitative data to explain the narrative found in qualitative data. Researchers use this design when there are no tools, variables, and measures available for the population under study [29]. Based on the research objectives and questions, a qualitative study was needed to explore the migration of health information systems in Iran and to initially identify the relevant factors and variables in order to obtain the initial design of the framework and secondly to design and validate the framework. The quantitative Delphi method was evaluated and validated in two stages of the designed framework.

Step One: Qualitative Study

The research population at this stage included experts in cloud computing and health informatics. (Table 1) Sampling continued until data saturation was achieved. The tool was an interview guide consisting of two main sections and 10 open-ended questions that were designed based on the literature review. Face-to-face interviews were used to collect the required data that averaged 37 minutes. The interviews were transcribed coded using open coding and codes were sent for approval by the interviewees. The open coding resulted in 773 codes extracted in tables according to the relationships between them based on axial coding and categorized. One team member reviewed the coding and categorization of the data. The final categorized framework is shown Fig 1.

Step Two: Quantitative

The migration framework was validated by 20 members, including four from the previous step. To validate the framework, a questionnaire including six questions sections was used. The questionnaire had 182 items. Five-point Likert scale was used to determine the components' validity based on importance, a very high score of five and a very low score of one. The face and content validity of the questionnaire was evaluated and approved based on the opinions of five faculty members. Questionnaires were sent by e-mail to the experts and in the same way they were collected. Data analysis was performed based on descriptive statistics. Gordon believes that in Delphi studies and the use of central statistical indices it is better to use the median rather than mean because the presence of outliers in the data spectrum may divert the result [30]. Armstrong

also finds it more appropriate to use median in data because of outliers [31]. The median over 75% in Delphi studies represents as acceptable range and between 50 and 75% subject to a second round [32]. The criterion of collective agreement was a median of 3.75 and above for each component based on expert opinion. Moderate items below 2.5 were eliminated.

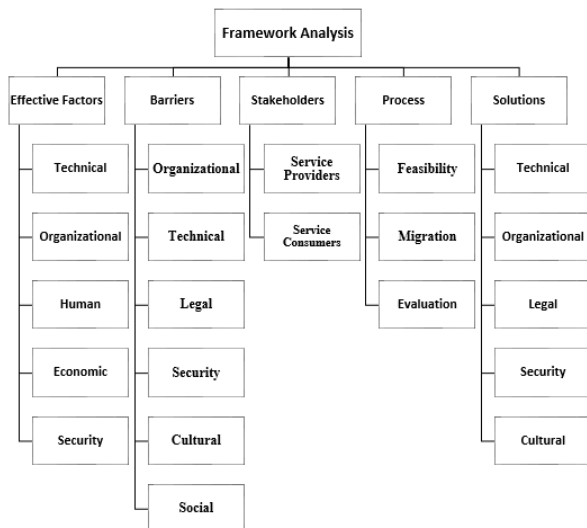


Fig 1: Final framework analysis

RESULTS

Demographic data of the participants in two quantitative and qualitative stages are presented in the Table1.

Step One: Qualitative findings

Based on a framework analysis, the data in this section were presented in tables and categorized according to the codes of the interviews. The findings of this section are categorized into five general themes of effective factors that were technical, organizational, economic, security, and human factors, barriers which include technical, legal, security, organizational, cultural and social obstacles. Stakeholders, including CSPs, which included supervisory and service stakeholders, and service consumers' stakeholders, which included side stakeholders, hospitals and supporters. Processes which included feasibility, migration, and evaluation processes and solutions which categorize technical, organizational, legal, security, and cultural solutions.

Step Two: Quantitative Study

After classifying and summarizing the first phase data, the research team extracted the initial framework, which included the following features and components (Fig 2).

Table 1: Demographic characteristics of the participants

	Items	Qualitative	Quantitative
Age	<30	1	1
	30-40	9	10
	40-50	2	9
Sex	Male	10	13
	Female	2	7
Education Field	Health Information Management	2	4
	Medical Informatics	5	8
	Computer Engineering	5	8
Education Degree	Master Of Science	3	2
	PhD	9	18
Work Place	University (Faculty Member)	5	18
	Research Centre	3	2
	Health Software Company	3	-
	Hospital (IT Manager)	1	-
Work Experience	<5 Years	-	4
	5-15years	9	9
	15-25	1	2
	25-30	2	1
	No Answer	-	4

After extracting data from the first qualitative phase, by tabulating and categorizing the contents, the initial components of the framework were obtained (226 subcategories, 57 categories, 21 subthemes and 5 themes). The research team re-assembled and summarized the data so that the initial components were comprised of 182 components, then plotted them into several images and discussed them, and given the relationships between the components, the final image as a result of discussion and consensus of the research team was drawn. This framework was validated in a two-stage Delphi study. The overall components of the proposed framework, which had 182 components, were approved by experts in the first round of Delphi, and a number of components of each axis, comprising 55 components, went into the second round of validation; 33 components were eliminated and 22 components were approved. The final framework was validated with 149 components. This framework had four general layers based on the role of stakeholders in the field of health and cloud computing in Iran. The framework layers included the government layer, the organizational layer, the technology and the executive layer. The beneficiaries include three groups of government, CSP, and service consumer stakeholders that have been suggested a set of processes depending on their roles.

DISCUSSION

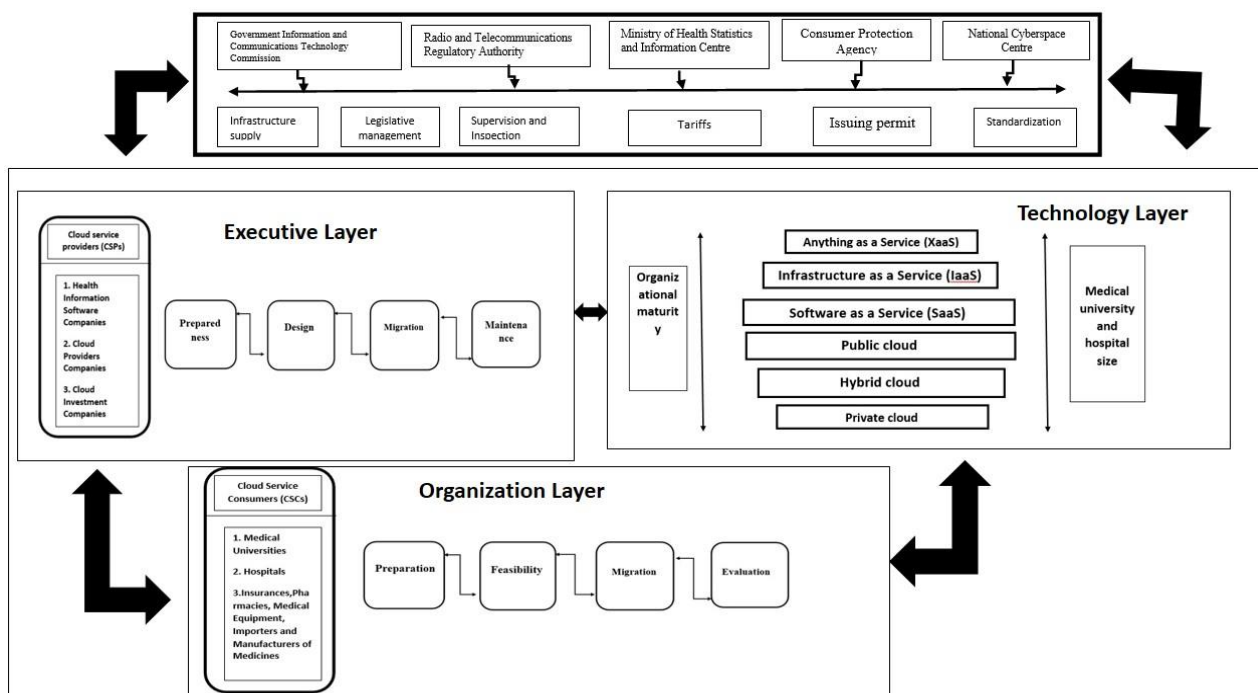
The study of cloud computing in the field of health has

been technologically devoted too much research [15] but less from an organizational point of view [16]. The effective factors discussed and less on the health-related migration framework have been addressed [16-20]. In general, related studies can be categorized into three categories:

Some studies examine factors affecting cloud adoption based on frameworks such as TOE, HOFIT, IS Triangular, and categorize the effective factors into human, technical, organizational, and environmental factors [17-20]. Based on the Gao systematic review, a conceptual framework for cloud adoption in the health system was presented that included five categories of technical, organizational, environmental, data/information variables, and stakeholders, the last two variables were specific to the health domain because specific data and information is generated to further the goals of care centers and, if combined with technology, will have greater results as well as health stakeholders who can

include different groups of physicians, nurses, insurance and other clinical and non-clinical staff who Each group according to its roles (public and medical) can influence the adoption of the cloud [33]. Sadoughi study reviewing the literature on cloud adoption in both health and non-health domains suggested a set of technical, organizational, environmental, and individual factors that have not been investigated in the health domain and need to be studied on these factors. Individual factor domains as well as frameworks such as TAM, DOI, and TRA were among the proposed domains for studying factors affecting the cloud migration [16]. The result of these studies is focus on identifying factors influencing cloud adoption and their ultimate goal is to assist decision makers by raising their awareness of the factors that influence them. But what a senior health system manager would need is to have a roadmap or framework to go through the cloud migration process with specific health features in place.

Fig 2: Health information systems migration framework on cloud platform



Studies examining the migration process have a large number and have examined this process from different perspectives. In all of these studies, a set of processes from the beginning to the end of migration to the cloud [6, 21, 23-26] has been proposed, among Bazi study based on the meta-synthesis method provides more detail and documented results [21]. Subsequently, systematic reviews of studies have provided a framework in this area [22, 28]. Jamshidi proposes a Reference Model for Cloud Migration that comprises 4 process categories Migration Planning,

Implementation, Evaluation and Cross Cutting Concerns with 20 Tasks and concludes that most studies on planning Migration has been focused and few address the concerns of cross cutting: governance, security, education, organizational change and multitenancy, and there is a need for further studies in this area. Gholami propose a framework that provides activities, features, and recommendations based on existing workflows. The strengths of this framework is its flexibility regarding the selection of requirements based on the features of the migration project and provides a reference

process model based on the available literature [28]. Evaluation of these studies concludes that despite the various aspects of cloud migration in non-health areas, there is a need for a separate study that incorporates specific health-related feature in cloud migration.

The third category of studies examining cloud migration in the field of health. Mero suggest a five-step framework including strategy, regulation and policies, technology, implementation and evaluation [27]. Although it examines certain features such as regulation and policies with respect to specific health requirements, there is still a need for a comprehensive study that utilizes a robust scientific approach to address specific health requirements.

The fact that a significant amount of cloud computing research is published each year, each reporting different solutions, experience reports, and recommendations for transferring legacy assets to the cloud, bears witness to this research area has reached a puberty point that requires the development of a general reference model [28]. But in the field of health, due to the limited number of studies, it has not yet reached the maturity point and is still in its infancy and needs further investigation with regard to the specific characteristics of the health field.

Reviewing the literature and drawing the following general conclusions required a comprehensive study and a framework that encompassed all aspects of health in the cloud migration: A review of the migration texts showed that the roles involved in the migration process were not well described and if done, would lead to better migration [28]. Given that there are specific roles in the health domain, it is necessary to include roles in migration process. In the present study, the processes were categorized according to roles in the health as well as in cloud provision based on four main layers which are discussed below.

Governmental layer

The role of government can be defined only in the area of legislation, standardization, monitoring, review of cloud-related activities and provide infrastructures.

The use of cloud computing will have many legal issues including contract laws, intellectual property rights, data jurisdiction and data privacy because cloud will distribute physical resources in different jurisdictions [34]. Despite the role of laws in facilitating migration to the cloud securely, the lack of laws is causing an obstacle in the cloud business [35]. Due to the sensitivity of the health data of a group of stakeholders from the Ministry of Health, they should be involved in the formulation of laws to meet the

specific requirements of this area when enacting laws. On the other hand, support for the formation of law firms that can advise health organizations when needed, as health care organizations may not have sufficient expertise in cloud computing and the existence of consulting law firms. Being able to provide the necessary guidance at the time of contract is very helpful.

One of the problems organizations face when migrating from one platform to another is non-compliance with the standards of communication, hardware and software areas [36]. Not only will the problems of care providers in cloud migration be reduced if the government oversees the use of standards, but also the monitoring of security standards will reduce the most important concerns of care providers in cloud migration. Because cloud migration in health organizations is slow due to security issues [4], the government is expected to accelerate this process by playing a protective and supervisory role.

Due to the distributed nature of cloud computing, there is a great deal of legislation and monitoring of CSPs, all of which should be better pursued by governments so that clients are not harmed. Governments, by controlling the economic operators of the cloud domain, in addition to controlling the market, are creating trust for clients. If only government-licensed activists are able to work in the health sector, healthcare organizations will be more confident about this technology. The government's regulatory role in setting cloud tariffs not only leads to lower costs but also moderates the cloud business market, encouraging health organizations to adopt the cloud as a service. It will be economical.

Executive layer

This layer was related to the CSPs and their executing processes. In the proposed framework, the role of the government was defined only as the legislator and policy maker, and the main implementation of the processes was left to the CSPs, which are generally from the private sector. The executive processes included preparation, organizational feasibility, infrastructure evaluation, service and solution design, migration and execution, ongoing evaluation, risk management and maintenance.

One of the primary issues from the experts' point of view was the launch of research and development units in health software companies in the country [37]. Also, connection with the cloud companies with the required technologies and the transfer of these technologies into the country, followed by other activities such as standardization.

Processes such as gaining top manager support, enhancing the managers' knowledge, and the gradual

migration of the cloud had the most agreement between experts. Given the structure of the health system in Iran, the majority of senior executives have clinical expertise and may not have sufficient information on IT, so it is important for the first stage providers to justify this range of managers [38, 39]. Top trustees in cloud can be considered as the most influential indicator of cloud adoption, and organizations with more knowledgeable cloud managers are more interested in cloud adoption [40, 41].

According to the framework, providers should evaluate the infrastructure of universities and hospitals regarding the possibility of migrating to the cloud according to dimensions like human and technology, which include technical specifications of government services, availability of network and software requirements, the degree of IT infrastructure automation, capable managers and relevant technical experience with negotiation and bargaining capability [23, 26].

In terms of service design and solutions, components such as assessing cloud solutions to hospital processes and using health and cloud computing professionals had the highest level of collective agreement. When there is a big difference between the cloud and the old systems, reengineering should be done. Therefore, the project manager must have sufficient resources, time and budget [42].

In terms of migration and implementation, the majority of respondents agreed with experimental migration and cloud formation at the three academic, regional, and national levels. The organization should decide whether to use cloud prototypes or to use pilot projects before the full implementation [21, 24, 27]. The development of a risk management program was also one of the dimensions that had the highest degree of agreement and was essential in previous researches [6, 23, 26].

Technology layer

In the technology layer, service and deployment models were considered as a spectrum; therefore, due to organizational maturity one can decide on service and deployment models. The higher the organizational maturity, the organization can move towards private models that allow greater control and organizations that are in the early stages of organizational maturity are better off using public cloud models [21]. That is to say, software-based service purchase models (SaaS) can be used for small, non-infrastructure hospitals, but for larger hospitals that have their own infrastructure, IaaS model can be used. The proposal is equivalent to the maturity level of hospitals with primary infrastructure. The ultimate goal is to model everything as a service (XaaS).

Regarding the deployment model, due to the size of the hospitals and the organizational maturity, small hospitals can use the public cloud model and they will only pay for the services, but the larger hospitals that have their own data center and significant amounts of data are available, can use private clouds. Cloud computing leads to the development of the market for small and medium-sized organizations [43], because they usually have less ability to provide infrastructure. So, these organizations are advantageously provided with cloud with pay per service model [44]. However, the interfacial state of the hybrid clouds can also be considered with respect to the sensitivity and volume of the organizational data. In fact, the use of private clouds is suggested because of the higher security for these hospitals that have strategic data.

Organization layer

This layer consists of four phases, preparation, feasibility, migration and evaluation and 12 steps that is described in following text.

Health organizations that intend to cloud migration should conduct SWOT studies on their affiliated hospitals and identify the first adapters and their geographical distribution to prioritize them for migration. In addition to determining the level of readiness of these centres in accepting clouds, assess their organizational, technical, and commercial readiness [6, 24, 25] and their performance in migrating to the cloud by determining success factors [42].

Universities should have a general assessment of human resources in the planning phase, including existing and required specialists and their needs so they can propose time planning based on available facilities and at the same time take action to meet needs. One of the most important measures is to evaluate the knowledge of users and managers and increase this index by holding seminars and workshops [24, 27].

In the feasibility step, universities based on the size and nature of its affiliated hospitals (technology layer) determine their needed services. In the process of attracting stakeholders, it is necessary to attract managers at different senior and middle levels. In evaluating infrastructure, it is important to determine the type of data that is to be transferred to the cloud. Considering the sensitivity of health data it is important to classify health data and evaluate those that can be stored in the cloud. The higher the sensitivity of an organization's data, the greater the likelihood of error from the provider leading to more damage to the organization, so organizations with more sensitive data are more likely to resist cloud adoption [40]. Respondents believed that

infrastructure provision should be gradual as the project progressed, on the one hand to recipients of infrastructure supply services, i.e. for small hospitals providing communications and network infrastructure and for large hospitals provide hardware and datacentre infrastructure.

In selecting the provider, a minimum set of criteria such as ability to provide scalable and flexible cloud resources, powerful security control programs, ensure the customers rights to control and access data, provide cloud service models in accordance with the organization needs, honesty and continuity of cloud services provision must be determined, documented and monitor providers according that. attention should be paid to the reputation and credibility of the provider, which is guaranteed by the licenses and certifications they have [45] as well as experience in the field of health and their customers support services [6, 35].

In addition to setting privacy standards and location of cloud servers, assessment indicators and how to determine service quality should also be specified in the SLA. A plan for periodic SLA reviews should be considered. Establishing cloud servers in the host country can be a solution to increase users' trust in the cloud [46, 47] decision makers should categorize selected applications and services according to their mission sensitivity, organizations can use private clouds for their sensitive data and for non-sensitive data from public clouds [21] in other words, hybrid models can be used to increase the security of sensitive data [48].

After implementation, in addition to reassessing the acceptance and users' needs, which can lead to increased cooperation and job satisfaction [49] by determine the quality evaluation indicators, the system should be assess periodically, availability, customization, interoperability, access ability and performance are indicators that should be considered [6, 23, 26, 50, 51] and, if necessary, in connection with the CSP, the required corrections should be made.

The final framework with features such as addressing a high level of detail, process layering, attention to stakeholders in the two areas of health and cloud computing, had innovation over the previous frameworks. Given the main purpose of the present study in providing an applied framework, a set of components has been proposed operationally so that health decision makers will be able to make better decisions about cloud migration by taking advantage of these suggestions. Executive processes were categorized according to the role of each group. In fact, previous frameworks have generally addressed the issue of migration and solutions have been proposed on this basis, while the migration process is

a very complex and detailed in the different technical, organizational, legal and regulatory areas and if different aspects did not considered, it may fail. In addition, the role of governments in previous contexts has not been explored. In addition to identifying government stakeholders, a set of processes has been defined for them. According to the stakeholders proposed in the framework, brokers can be defined in two categories: commercial cloud brokers and technical cloud brokers. The formation of law firms with government support, could be considered as commercial brokers and companies providing health information software services can also be defined as a technical broker that acts as an intermediary between CSPs and clients, i.e. hospitals and medical universities.

CONCLUSION

Although the present framework is tailored to the interests of Iran's internal stakeholders and processes, it will be applicable to all countries with a private state-owned care system. The separation of stakeholders and the processes associated with them can be a good model for other cloud migration organizations and cost-effective solutions for managing HISs. Due to the lack of knowledge of health executives on cloud computing, they may not be able to make appropriate decisions on whether or not to migrate, so having a comprehensive framework in addition to enhancing the knowledge of managers and decision makers will also help them make better decisions, but also a roadmap for successful migration.

ACKNOWLEDGMENTS

The present study was a part of PhD dissertation that is financially supported by Iran University of Medical Science by grant No IUMS/SHMIS-1394.9221563203 and was approved by Ethics Committee of Iran University of Medical Sciences whit this code: IR.IUMS.REC.1394.9221563203

AUTHOR'S CONTRIBUTION

All authors contributed to the literature review, design, data collection and analysis, drafting the manuscript, read and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this study.

FINANCIAL DISCLOSURE

No financial interests related to the material of this manuscript have been declared.

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