J Clin Res Paramed Sci. 2021 June; 10(1):e102448. doi: 10.5812/jcrps.102448.

Published online 2021 March 8. **Research Article**

Improving the Performance of Hospital Information Systems Using Six Sigma for Kermanshah Province Hospitals

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Received 2020 March 09; **Revised** 2020 October 24; **Accepted** 2020 November 01.

Abstract

Background: Performance improvement in hospitals requires an appropriate model for performance evaluation. Because organizational goals cannot be achieved without a comprehensive model for evaluating and reviewing programs, organizations cannot apply effective management of programs without regard to the results of their activities.

Objectives: The purpose of this study is to introduce a new model for improving the performance of hospital information systems using Six Sigma method in Kermanshah province hospitals.

Methods: This is a qualitative research based on content analysis and Delphi method. The data are collected through semi-structured interviews and the participants are 19 experts in hospital performance systems which were selected by snowball sampling. After transcribing the interviews, three steps were done using content analysis: firstly, using line-by-line coding (or open coding) words and segments of interviews were coded, secondly, each code was conceptualized and categorized into some axial codes based on focused coding, and finally, selective coding was done in which categories were identified based on axial codes' similarity, conceptual relationship and common characteristics.

Results: The results of the coding of the interviews showed that variables such as reduction of medical errors, improvement of hospital quality of services, promotion of hospital efficiency and productivity, quick and easy access to information, increased patient satisfaction and safety, management and cost reduction, and time management and control influences the performance of hospital information systems.

Conclusions: For improving hospital information systems, hospital managers and system developers should not only pay attention to variables which are controlled by the software and are least affected by the human resources of the organization; such as: cost control, quality control, information control and time control but also human based variables such as specialization of the staffs, their motivation, reduce errors and etc., which are sometimes neglected.

Keywords: Quality Improvement, Health Information Systems, Systems Analysis, Hospitals

1. Background

The most important characteristic of a powerful society today lies in prioritizing the hidden information element, to the extent that the present society is called the information society (1). Therefore, systems must be set up to generate and manage information (2). An information system is a combination of technologies, people and processes used to acquire, transfer, store, manipulate and display information (3). Hospital information system (HIS) is a comprehensive software to integrate patients' information to send and exchange comprehensive patients' information between departments and other medical centers to expedite the process of patient care and treatment, improve quality, increase satisfaction and finally, reduce costs (4). Since health care centers are responsible for maintaining the health and treatment of patients, many developed countries are beginning to accelerate treatment by providing timely information and facilitating matters such as medical education, medical and paramedical research and development and optimization of management practices in health centers; these centers were equipped with a hospital information system (5). A complex organization with multiple departments, such as a hospital, needs to access to information every time and everywhere it is needed. Using computers is the only way to collect, store, communicate and deliver large amounts of information (6). This has led to a growing demand for information systems in the healthcare industry, and hospital informa-

tion systems are being frequently developed and implemented, but ICT advocates pay less attention to the need to evaluate these systems independently (7). The role of information in timely and appropriate decision making is unquestionable; therefore, information is referred to as power (8). Hospital information systems are electronic tools that collect, classify, maintain, and retrieve patients' financial, administrative, and clinical information using computer capabilities and transfer them to decision makers anytime and anywhere (9). The hospital information system not only improves decision making in health care delivery by providing patient information and records to the service providers, but also plays an important role in the development of organizational performance (10). The role of the hospital information system in improving the performance of hospital management and its medical staff is undeniable, and most scholars and management leaders have undoubtedly recommended its use; managers believe that it is inevitable to use it to transform hospitals (11). The hospital information system enables the hospital's IT manager and other role players such as doctors, nurses and other executives to access the information needed to make decisions at any time and place and to make decisions based on actual workplace information. Managing decisions based on real information leads to increased efficiency and development in hospital's performance and ultimately to its efficiency and effectiveness (12).

Nowadays, business intelligence (BI) and healthcare analytics are two emerging technologies which need to be mixed in order to help healthcare industry to provide better and faster services to the society (13). But Iranian hospitals have not yet started to upgrade their information systems to be suitable for business intelligence. This is because there is not a single strategy for developing information systems in Iran and governmental executives do not see the healthcare system as a whole. So there is different and sometimes incompatible policies, strategies and applications in Iranian hospital information systems development. As health information systems in developing countries are increasingly digitalized, interaction with old analog technologies is replaced by digital user interfaces for health institute staffs. Literature shows that usability problems in such initiatives, arguing for their adverse effects on the users, and the system as a whole (14). Given the role of hospital information systems in informing hospital service providers and staff, this study is trying to improve the performance of hospital information systems using the Six Sigma method.

In the past few years, Six Sigma method in management has entered the healthcare sector. Six Sigma methodology can change the face of the hospital and the health care system as a whole and improve service delivery. Competition in the health sector has forced the healthcare system and hospitals to find effective and efficient ways to improve their output by improving the quality of hospital products and services and reducing patient dissatisfaction. As the hospital is expanding and becoming more complex, errors, service failures and difficulty in providing health care are increasing day by day. Most governmental hospitals operate at three or four sigma levels to reduce the errors for reaching the desired level, but reducing errors and service failures in the private sector is better than the governmental ones. Six Sigma seeks to coordinate quality, cost of treatment, and treatment process with each other by using statistical methods and control mechanisms. Studies have shown that the higher the sigma level of an organization, the better the level of its service provided. For example, with the implementation of the three sigma levels, there will be 6.7% errors per million, and with the implementation of the six sigma level, there will be 3.4% errors per million (15). In the year 1998, a medical institution conducted an overall assessment showing that 98000 people die each year due to medical errors and 400 million dollars is spent on medical malpractice complaints each year (16).

Zainali, et al. (1986), in their research titled "developing an interoperability model to interact in hospital information systems", concluded that achieving interoperability due to the complexity of information systems, diversification of information and standards is a very difficult task in the field of healthcare. These challenges include technical, syntactic, semantic, and organizational issues. Increasing the degree of interoperability and compatibility between hospital information systems will facilitate the interoperability of systems with each other and increase the efficiency, clinical and managerial efficiency of these systems (17). In a study entitled "investigating factors affecting hospital information system adoption by nurses based on technology acceptance model", Baratpour et al. (2018) showed that nurses in Zabol hospitals generally have a good attitude towards hospital information system adoption. But due to the high volume of work, long queues, lack of staff, insufficient training programs, and lack of computer systems, their attitudes towards the usefulness, ease and use of hospital information systems are moderate (18). Phichitchaisopa and Naenna, in a study conducted in (2013) entitled " factors affecting the adoption of healthcare information technology", used a questionnaire to assess 400 employees including physicians, nurses and hospital staff in Thailand based on (UTAUT) model; they found that information technology gives hope for improved performance, hope for effort, and facilitates conditions. They also achieved a significant impact on behavioral goals on the use and acceptance of information technology, and

that the quality and performance of technology helps hospital staff understand its usefulness. Therefore, technology in health care should be supported by providing good quality, through services and information technology that makes data well processed. Some health care systems do not have to incur high costs for these technologies, they can support their performance through expected and predictable factors. Individuals involved in the health care system should provide equal support and services to users in order to develop high quality and sufficient technical skills in health care technology (19).

2. Objectives

Due to the importance of hospital information systems in the overall quality of services delivered by a hospital, the most important objective of this study is to introduce a model for improving hospital information system performance based on Six Sigma method. In another words, the main question of this research is this: What Six Sigma model can improve the performance of hospital information systems?

3. Methods

This is a qualitative research based on content analysis and Delphi method. The data are collected through semi-structured interviews and the participants are 19 experts in hospital performance systems which were selected by snowball sampling. 13 of them were male and 6 were female. Their average age of the Delphi panel was 43.6 and their average work experience in hospital information systems was 13.2 years. Ethical considerations were also taken into account when conducting the research, which indicates the extent and nature of the researcher's respect for the contributors. Inclusion criteria for the study participants were: their specialized knowledge and experience in hospital information systems, having experience working with these systems, and conducting research in this area. After transcribing the interviews, three steps were done using content analysis: firstly, using line-by-line coding (or open coding) words and segments of interviews were coded, secondly, each code was conceptualized and categorized into some axial codes based on focused coding, and finally, selective coding was done in which categories were identified based on axial codes' similarity, conceptual relationship and common characteristics. The gathered data from Delphi method first was analyzed by one of researchers and the contents which were near the main subject of the research extracted as some codes. These codes then were used as keys for interviewees to make them more active in introducing new contents about the subject, which were useful in clearing the unknown aspects of the subject. Methods for ensuring validity of the results from Delphi method could be explained in two ways: face validity and content validity. Face validity indicates how questions which were asked in Delphi method visually similar to the subject being prepared for measurement. For this mean, opinions of experts (university professors) were asked. A measurement tool has content validity when it considers all the different aspects of the structure in question. Content validity is often measured by the knowledge of relevant individuals and professionals. Because the Delphi panel were experts in the subject of the study, the content validity is ensured.

4. Results

In the first step, 136 initial codes were extracted from the contents of the interviews, and then the common codes were categorized into themes or categories. The results of open coding is listed in the Table 1.

Axial coding is a series of procedures that relate data to each other through the link between categories and the subcategories. As such, axial coding refers to the process of forming categories (primary and secondary). This is done using a paradigm (paradigm model). To illustrate the relationships between the dimensions as shown below. Finally, the selective coding can describe the dimensions of the pivotal phenomenon of the research or the core category. The pivotal phenomenon studied in this study is to explain the dimensions and components of improvement of hospitals' information systems that are presented in Table 2.

The final model of the study is shown in Figure 1.

5. Discussion

For improving hospital information systems, hospital managers and system developers should pay attention to variables which are controlled by the software and are least affected by the human resources of the organization; such as: cost control, quality control, information control and time control not only could be set automatically, but also could be processed due to the determined aims of a hospital within an information system to measure the gap with the desired level in Six Sigma approach. These variables are systemic but there are other human based variables which are very important. Variables such as specialization, which is determined by management and leadership has an important role in improving the hospital information system

Table 1. The Results of Open Coding Analysis

Categories	Open Codes
Reducing medical errors	Reduction of patient's drug paradox error; Increased accuracy of laboratory results imprudence; Carelessness; Lack of skills; Drug side effects; Nosocomial infections; Wound infection; Pressure ulcer; Mistake or delay in diagnosis; The patient falls from the hospital bed.
Improving the quality of hospital services	Better service, daily statistics and reports; Accelerate inter-hospital communication; Increase the accuracy of insertion of information and requests that are unreadable manually; Eliminate duplicate and unnecessary procedures; Drug administration in the system; Quality improvement of health services.
Improving hospital efficiency and productivity	Achieve a nationwide distributed database; Connect with global health networks; Use of integrated systems of information instead of inter-departmental systems; Quick and easy decision making by hospital managers; Communicate with other medical systems.
Quick and easy access to information	Use of hospital information system data for planning in clinical and epidemiological research; Refer to previous file information; Extract statistics and information in faster ways; Pharmacy inventory control; Easy access to medical records; Rapid file retrieval for various purposes such as research and study of relevant students; Receive and accurately record patients' identity and medical information; Providing patient information and records to service providers; The replacement of manual files with computer files; Report system test results.
Increased patient satisfaction and safety	Patients' satisfaction with expediting; Increasing the quality and development of health care services; Accelerate the process of patient care and treatment.
Manage and reduce costs	Information about hospital income and expenses; Use effective costing systems; Reduce health care costs; Cost effective management.
Time control and management	Reduce patient transfer time; Accelerate the formulation and circulation of records in the hospital; Reduce clearance time; Reduce Physicians' writing order time and para-clinical requests; Reduce the time to get answers; Reduce admission time.

Table 2. Open Source and Subcategories and Pivotal Phenomena

Core Category	Selective Coding	Axial Coding	Open Coding
Improve hospital information systems	Specialization	Management	Organizational role of managers
		Leadership	Reduce errors
	The human factor	Psychological	Motivation, empathy, responsibility
		Productivity and efficiency	Increase effectiveness
	Skill	Contact	Correct communication
		Expertise	Having expertise
		Courtesy	Patient safety
	System	Cost control	Reduce costs
		Quality control	System quality control
		Information control	Easy access to information
		Time control	Time control

quality. Unfortunately, most of Iranian hospitals, lack experienced information system managers and use technical engineers as managers. Managers with the expertise in information systems and an academic background in human resource management can help hospitals to better manage the whole cyclical data process in the information system and further, direct all initiatives in information systems as a leader.

The third dimension -skills- describes the level which staffs of a hospital can handle the patients' related processes appropriate to the needs of them. Not all of hospitals view the patient as a customer; in another words, they fail to transfer this central believe to their staffs. Creating a customer relationship management system (CRM) for creating and maintaining long term relationships with patients could be useful in reaching this aim. Also, training staffs with the most novel courses in relationship marketing has a great outcome and makes hospital more compatible with marketing concepts. Finally, The Human Factor refers to human related factors perceiving and using the hospital information system and the degree which a new implemented system is applied. The best and most expensive information systems are not effective until the employees which the systems are designed for helping them in their jobs, perceive them useful and use them in their daily operations. Most of literature supports this theory such as technology acceptance model (TAM) (20) and unified theory of acceptance and use of technology (UTAUT) (21).

The results of this study indicate that effective and practical use of Six Sigma method can identify effective factors in improving the performance of hospital information systems and increase patient's safety and satisfaction, cost control, time management, medical error reduction, availability and providing information in an effective and easy manner, improving the quality and services

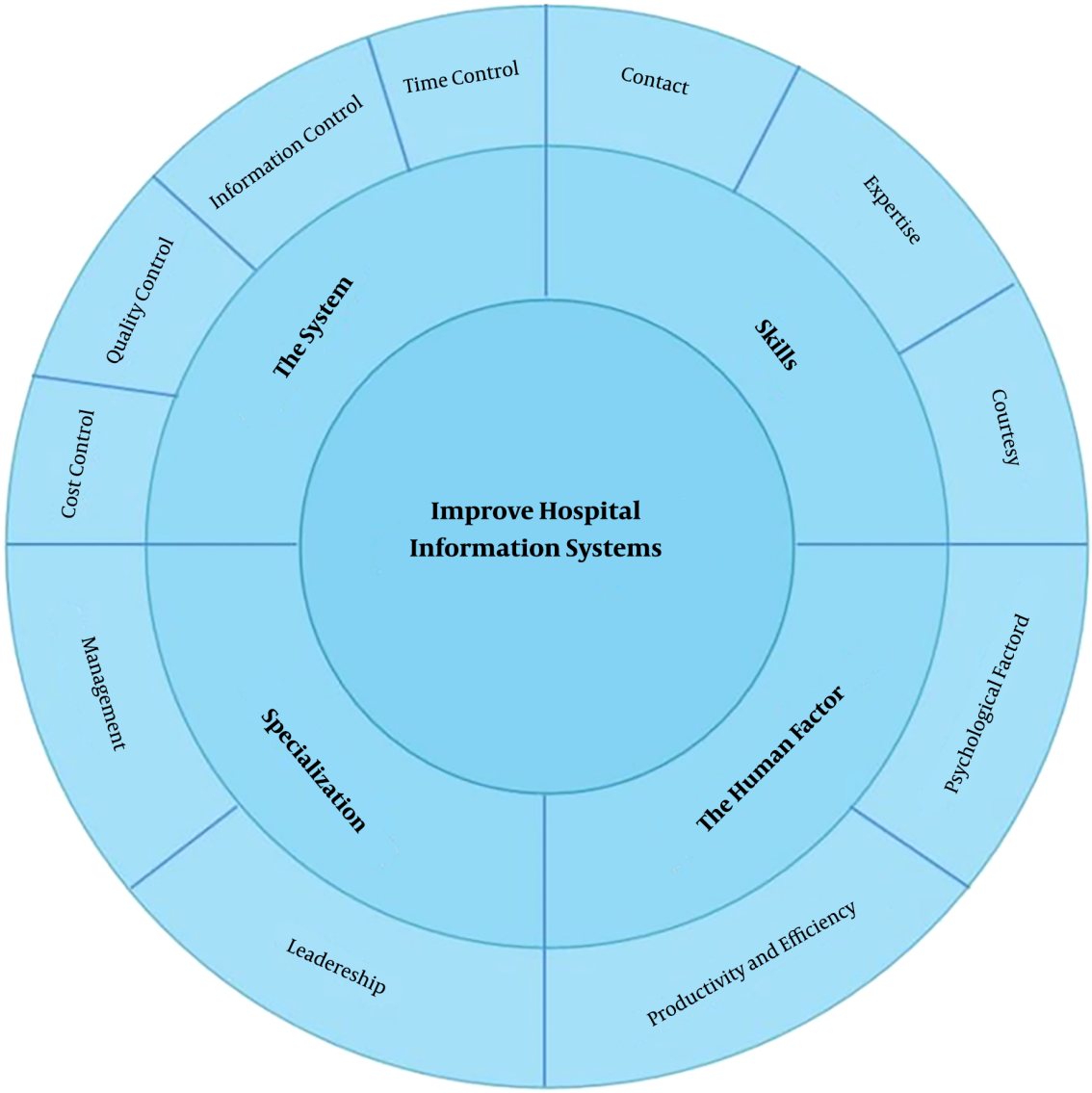

Figure 1. Proposed model for hospital information systems improvement

provided in clinical care, and overall enhancing the effectiveness and efficiency of hospital systems. The importance of the Six Sigma methodology is highlighted when the treatment system is directed to safer, faster and more coordinated care, and to lower mortality, lower error, better response to needs, and better utilization of resources through the use of the Six Sigma methodology. The implementation processes of this method include definition, measurement, analysis, improvement and control. By applying this approach to the hospital, firstly, the problem will be defined from all angles; secondly, then criteria and checklists for measuring it will be determined. The information obtained will be analyzed through checklists, and identifying existing barriers will help to address them. Finally, feedback and control of the processes will be provided. Such implementation of this approach will improve the efficiency and effectiveness of hospital quality control.

The proposed model in this research can enhance the overall quality of a hospital by: (1) minimizing error and cost variance; (2) increasing patient's satisfaction; (3) making staffs happier and more productive; (4) reducing the time of prescription in hospital pharmacy; (5) minimizing

patient's medication paradox error is minimized; (6) improving patient's safety by reducing medical errors; (7) increasing the accuracy of laboratory results; (8) reducing the time wasted in preparing medical reports; and (9) reducing patients' reception and discharge.

The proposed model is designed based on Six Sigma approach which is a systematic, statistical approach aimed at identifying process performance deficiencies and reducing the error of those business and clinical processes that result in long time, high cost and poor outcomes. Experimental results in the various countries that have implemented the Six Sigma approach in health care institutions have minimized the impact of this approach on improving cycle times and patient turnover in the emergency department, operating room, radiology services, laboratory, supply management, antibiotic treatment management, improving the hospital staffing schedule, reducing medical error and saving money. Proper hospitalization and continuing education are also among the requirements for its implementation.

The hospital information system has many added values and capabilities and can revolutionize healthcare and hospital services. Improving the quality of health care, creating scientific management in the hospital, improving the economy of treatment, enhancing research in the medical sciences, providing desirable medical information services, reforming macroeconomic policy in health care, and expanding medical education are among the fruits of this system. Global research also confirms these favorable effects. Therefore, planning, setting up and deploying the hospital information system optimally is essential and can revolutionize the type and quality of health care delivery, and related research activities.

Footnotes

Authors' Contribution: Mohammad Javad Jamshidi proposed the subject and developed the research plan; Mahdi Hosseinpour reviewed the research plan and critically edited final manuscript; Hamed Heshmati extracted the theorical foundations and and Bahar Fathi extracted the codes and designed the study's final model.

Conflict of Interests: The authors declare no conflict of interests.

Funding/Support: This research received no external funding.

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