Clinical Decision Support System in HealthCare Industry
Success and Risk Factors

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Abstract **- By using information technology, the healthcare industry is rising rapidly, through automating number of processes such as analyzing records, organizing the huge data, and developing workflow by extraction and maintain knowledge. In the last few years, Decision Support System (DSS) considered as the most outstanding system, which is crucial for any healthcare organization. The aim of this paper is to present an overview of using DSS in healthcare industry by focusing on benefit of adapting clinical decision support system, its success and risk factors that must be taken into account during implementation process, and Barriers to CDSS Implementation.**

Index Terms - healthcare, Decision Support System, Clinical decision support system DSS, CDSS.

INTRODUCTION

Decision Support System (DSS) can be defined as an application that examine a huge data and present the result of that examination and analysis to help users in making more effective and reliable business decisions. DSS considered as "informational application" that is totally opposite of "operational application" where data is organized to serve normal and routine business operations. In general, DSS architecture consists of three critical components. Knowledge base, model and user interface. The complementary between those components empower the process of decision-making by generating strong evidence that leads to create a competitive advantage [1].

By using DSS, technology will integrate effectively with managerial decision-making process. This integration provide organizations with a lot of benefits such as: opportunity to save time by reducing decision cycle time, improve organizational control by analyzing data effectively and create knowledge, increase satisfaction of decision makers by providing them with better perception regarding complex information. Finally, the most important benefit is gaining a competitive advantage over other organizations that do not use DSS.

In many industries, Decision support is a significant function for decision makers it helps them to interpret complex information and generate a foundation for reliable decision. In healthcare, Decision support systems are designed to create a professional environment and provide case specific advice by integrating patient data, medical knowledge base, and an inference engine. A clinical decision support system (CDSS) can be used by: health care professionals or physicians, in order to prepare a diagnosis and to reinterpret the already specified diagnosis and improve the final result [2].

This paper divided into seven sections. The first section displays an overview of using decision support system in healthcare industry. Second section covers the concept of clinical decision support system (CDSS). Third and fourth sections talk about critical success factors and risk factors of CDSS. Fifth section provides an overview about the critical issues regarding CDSS. Finally, the last section presents the barriers to CDSS implementation.

DSS IN HEALTHCARE: AN OVERVIEW

In the last decade, Healthcare businesses have witnessed a rapid growth by employing Information Technology in the automation of many of their processes such as transaction, saving inventory and maintaining records, which results in eliminating routine and repetitive processes. Healthcare can be defined generally as the management and the treatment of sickness with the aim of providing effective services to the patient [3]. The amount of data produced in the healthcare business is huge; consequently, there is always a chance of incorrect diagnosis that may lead to drug reactions and allergies for a patient. Therefore, Information Technology is, used widely to capture and transfer information. Such system that helps the healthcare professionals in the problem solving process throughout the medical diagnosis is the Decision Support System (DSS) in order to confirm the correct diagnosis and reduce medical errors [4].

DESIGNING OF DSS IN HEALTHCARE

When designing DSS for healthcare, stakeholders and different types of decisions should be considered. DSS designers should keep in mind the organizational design and

structure including decision-making procedures, strategic planning process and governance structure as they proved to be important for any system effectiveness.

Models and methodologies used in designing the DSS also proved to relate to system effectiveness. Three approaches available: 1) Clinical algorithms, 2) mathematical and computational approaches, and 3) heuristics approaches.

Moreover, medical knowledge contains different patterns. From the literature, neural network systems prove to provide important planning of patient care, such as, the patient's length of stay and mortality rate. However, more researches needed to implement DSS by this methodology as it was only limited for laboratory or medical imaging applications.

Data mining is another common heuristic approach that is used to distinguish rules or patterns of different problems. DSS used the retrieved data from the data mining, which can help in reducing cost and improve quality of medical care. A famous system that represents the cooperation between knowledge management and data mining methods in enhancing the quality of health care services is Strategic Healthcare Decision Support Services (SHDS) [5].

CLINICAL DECISION SUPPORT SYSTEM CDSS

In healthcare field, decision support systems that support clinical decision-making are recognized as Clinical Decision Support System (CDSS). Clinical Decision Making includes the process of improving and enhancing the quality of health related decisions and actions that are performed during patient care, organized clinical and patient information in order to achieve better healthcare delivery. The decision making process depends on healthcare professionals ability and their knowledge of the related issue [6]. The healthcare professionals take the advantages of clinical decision support system to ease the complex process of every day patient care practice. Clinical Decision support system (CDSS) helps in enhancing patient care and minimizing practice difference by ensuring the delivery of clinical knowledge and patient-related information intelligently and at appropriate timing [7]. The main advantage of CDSS is that it helps in improving patient care and the efficiency of the healthcare providers, support healthcare professionals in diagnosing and analyzing the medical case [8].

CDSS can be defined as a software tool that can support clinicians, patients and other health care stakeholders in clinical decision-making process in such a way that the characteristics of a specific patient corresponded to a computerized clinical knowledge basis and information, and then assessment or recommendations for this specific patient are presented in intelligent way and at appropriate times to the professionals in order to enhance health and health care [9] [10]. Throughout this process, when healthcare professionals receive patient information they must input it into the system where its interacted with the stored related knowledge and the best suggestions offered is chosen and provided as an output to the healthcare professionals to choose the best useful information for quality decision making thru patient care.

A clinical decision support system by using artificial intelligence, can be programmed with the electronic health records, hospital information system or any other information system available in the hospital in order to abstract vast amount of patient data, search and analyze the complex pattern and organization which may sometimes lost by even specialists [11].

SUCCESS FACTORS OF CDSS IMPLEMENTATION

The use of Clinical decision support systems has increased recently and showed an improvement in productivity and performance, reduce medication errors and increase the quality of services in hospitals. However if users or health professionals are not likely to use the system, then hospitals cannot benefit from the implementation of CDSS.

Health professional play an important role in the system adaption, decision making and implementation process. Therefore, their acceptance to the systems in considered one of the most important factors that can affect the success of CDSS [12].

Three main areas assisting in the successful deployment of CDSS had been suggested by [13]: 1) The input data entry and the decision algorithms, 2) the human-computer interaction and 3) the output of the CDSS.

I. Input to the CDSS and decisions algorithms

The system should require the minimum amount of information and reduce the time spent in manual data entry by the physician, which will result in greater satisfaction with the system and ensure more time for patient care [14]. By implementing CDSS manual data entry should be reduced. A successful CDSS can obtain the data with limited intervention from the users.

Another important issue is maintaining the CDSS decision algorithm updated periodically and automatically, as patient management changes from time to time and CDSS cannot be outdated. In the past some CDSS were created with soft funding and when the funding consumed, it was difficult to keep the system up to date. Thus, it is essential that systems designed with automated updating features.

II. Human Computer Interaction

Human computer interaction is a critical factor that affects the success of CDSS. One important characteristic of the human- computer is the user-interface. It must be user-friendly, perceptive and offer easy access to information [14]. Users and physicians should have easy, fast and on the same time secure access to the system. As a result the Decision Support System designed should require the least

time from physicians as possible including time for login and obtaining required information [15]. CDSS sometimes lengthened the patient consultation period which my affect physician decision of adopting the system. A study was done by [16] on internet health application that was designed to assist physician in deciding if the patient needs a referral to another care giver or not. The majority of physicians planned to use the application if the time added to patient's consultation was less than two minutes and do not exceed five minutes. Furthermore, System should be accessible by physicians from different interfaces such as mobiles and other devices and not restricted to single location [15].

III. Output of CDSS

System output format and type should be reliant on what physicians needs from the CDSS, as every physician has different habits in his work and thus may have different requirements for a specific function. In this way, the development of an effective CDSS become more complicated, nevertheless important for a successful deployment, as information should be delivered in simple and efficient way. CDSS should add more clinical value, enhance the quality of health care and reduce its cost. CDSS must suit into the physicians' workflow and be able to deliver valuable information [17] [15].

To accomplish a successful deployment of the CDSS as a part of the physicians' workflow, CDSS must be designed working closely with the system users and tested for its usability. Some required features of CDSSs include smart information and alerts. In order to achieve the clinical and economic benefit of adopting the CDSS, clinical decisions alerts numbers should be balanced and only necessary number of alerts are giving. Although, giving too many alerts can cause disturbance to physicians especially false alerts, some physicians favor more alerts than others who only want to be notified for the very critical ones. That's why working with users during system development is very important [16].

RISK FACTORS OF CDSS IMPLEMENTATION

There are four critical factors classified as risk factors of clinical decision support system (CDSS) that may lead to failure or unreliability of decisions. Those factors are: Full dependency on knowledge base, Way of managing the knowledge, complexity of clinical workflow, and non-effective analysis of clinical data [18].

I. Full dependency on Knowledge Base

Decisions created by CDSS are fully dependent on knowledge base, which is the critical component of any decision support system in any type of industries. Lacking of accurate clinical dataset repository will lead to failure of diagnoses and advices, which is totally unacceptable [1]. Moreover, algorithms of CDSS such as Genetic algorithm, and ant colony algorithm require both accurate and high-qualified data warehouse to examine and retrieve knowledge that supports decision-making process [18].

II. Way of Managing the Knowledge

Managing the knowledge can be defined as a process of retrieving, interrupting, analyzing and capturing information in order to create the best use of knowledge. Implementation of high-qualified knowledge management is essential factor to generate useful decisions [19].

In healthcare industry, way of managing the knowledge is crucial in enabling healthcare providers of resisting new symptoms and diseases. However, the way that followed in managing the knowledge should be based on correct and accurate dataset.

III. Complexity of Clinical Workflow

In healthcare the clinical workflow is complex and doesn't consider as easy or routine work that can be managed easily. At any moment there is a possibility of unexpected event that require both rapid and correct action. This unexpected workflow considered as one of the biggest risk factor that may lead to make errors in advices or in diagnoses [2].

IV. Non-effective Analysis of Clinical Data

One of the significant risk factor that may lead to unreliability of CDSS is inefficiency of analyzing clinical data. Clinical data are huge and complex because of that analyzing them is not easy. There is a need for specialized analyst who has knowledge of how to extract data and making decisions.

ISSUES IN CDSS

CDSS applications although they have proven to be effective and efficient, they have not yet obtained wide acceptance and use in healthcare due to the many factors such as [5] [20]:

- Complexity of the system as huge amount of knowledge base need to be extracted in order to reach a decision.
- Time consuming for doctors and nurses as they usually deal with many complex diagnoses and don't have enough time to accept new systems.
- Lacking of decision accuracy as only few applications have reached the high level of accuracy that matched the diagnostic performance of medical professionals [21].
- Lacking of system usability as early-developed systems were not user friendly and required a lot of training [17].

- Systems don not usually provide clinicians workflow integration and the available tools do not provide clinicians with all information types they need in their diagnoses such as plan of treatment.
- Patient information mostly is unstructured and Natural Language Processing algorithms (NLP) are usually used to analyze it. However, these methods are still not sufficient for clinical applications [22]
- Lacking of decision-suggestions Explanation and scientific evidence [23].

BARRIERS TO CDSS IMPLEMENTATION

Implementation process of clinical decision support system faces some challenges and barriers. According to study conducted by [18] the major barrier is health care provider resistance. There are some reasons of resisting to change such as: Physicians believe that the implementation of CDSS will lead to minimize their productivity, which directly affect financial reimbursement. Another major barrier to adoption CDSS is budgetary constraints i.e. high cost of implementation process.

CDSS cost structure can be categorized into:

- Cost of analysis
- Cost of design
- Cost of System customization
- Cost of Implementation and testing process
- Cost of Training
- Cost of Maintenance
- Cost of Support

User training is one of important challenges that should be considered during implementation. A majority of CDSS failure reasons result from inefficient and improper user training [1]. There is a strong need to effective training program which depends on CDSS user's skills. Another anticipated barrier to the adoption of clinical decision support system is overloaded of information. According to [19] CDSS systems retrieve, extract, analyze, manage, and find relationship among billions of bits of information, with managing this huge amount of information in order to optimize the CDSS to generate the useful data that give users the best view of the health organization's operations [2]

CONCLUSION

DSS has emerged as one of the leading information technology tool for decision-making in healthcare. In health care industry, clinical-decision-support systems (CDSSs) have been used for many years and proved to have significant effect in improving patient care. When developing CDSS many factors should be considered in order to ensure the success of CDSS implementation and avoid its failure. These factors need to be applied at all phases of the CDSS development life cycle.

In this paper we focus on how clinical decision support systems enhance both of productivity and efficiency of overall health services, success factors and barriers to successful CDSS implementation.

FUTURE WORK

As a future work, we plan to build model, which combine benefits of both clinical decision support systems CDSS and Electronic Health Records EHR to improve quality of health services and facilitate diagnosis process.

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