Reasearch in Healthcare DSS: Where Do We Go From Here?

W. Heath Landrum  
*Auburn University*, landrwh@auburn.edu

Joseph R, Huscroft  
*Auburn University*, huscrjr@auburn.edu

Todd Peachey  
*Air Force Institute of Technology*, todd.peachey@afit.edu

Dianne Hall  
*Auburn University*, halldia@auburn.edu

Follow this and additional works at: [http://aisel.aisnet.org/amcis2008](http://aisel.aisnet.org/amcis2008)

**Recommended Citation**

[http://aisel.aisnet.org/amcis2008/358](http://aisel.aisnet.org/amcis2008/358)

This material is brought to you by the Americas Conference on Information Systems (AMCIS) at AIS Electronic Library (AISeL). It has been accepted for inclusion in AMCIS 2008 Proceedings by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.
Research in Healthcare DSS: Where do we go from here?

W. Heath Landrum  
Auburn University  
landrwh@auburn.edu  

Joseph R. Huscroft  
Auburn University  
huscrjr@auburn.edu  

Todd Peachey  
Air Force Institute of Technology  
Todd.Peachey@afit.edu  

Dianne Hall  
Auburn University  
dhall@auburn.edu  

ABSTRACT

Medical professionals make costly and critical decisions constantly in their practices. They have a need to do so quickly and efficiently and with as much information as possible. Important decisions are as diverse as critical patient needs to office practice issues. Researchers have begun to explore how decision support technologies can be used to facilitate the many needs of the healthcare industry from medical practices to hospitals. Research has shown that using decision support systems in healthcare has great promise, but many research questions have been left unanswered and in some cases, unasked. In this work, we begin the process of identifying gaps and future research directions.

KEYWORDS

decision support systems, DSS, knowledge, healthcare, medical, medicine, agents, health information, technology, systems

INTRODUCTION

Information is a critical necessity for effective and timely decision-making. In few places is this more evident than in the healthcare industry. When accurate and timely decision support is lacking, individuals may face prolonged recovery, difficult side effects, or chronic issues as a result of decisions made without benefit of enhanced support. At worst, incorrect decisions or actions taken too late may claim lives. This is true not only in emergency rooms, but in practices, clinics, and hospitals. Critical decisions may also need to be made on information that is widely dispersed across a number of platforms. Thus, not only is localized decision support a necessity, but also wide-ranging information bases on which to found decision support.

There are many different technological advances in place or in development for specific use in the healthcare industry. One such advancement comes in the form of systems that assist in the decision making process. Decision support systems have implications for nearly every angle of the healthcare industry, including patients, providers, and payers. This paper will discuss the research pertaining to the impact on practitioners and patients. It will point out opportunities for decision systems integration and areas in which more research is needed.

FRAMEWORK

For a research framework, a synthesis of two separate frameworks from DSS literature and healthcare literature was built. A research outcomes framework was taken from a study by Daniel Stryer et al (Stryer et al., 2000). This framework attempts to examine the impact of research on the healthcare industry as the research affects each level to eventually reach an affect the overall health system. Our adaptation of this framework which we will follow in this study can be found in Figure 1.

Figure 1 is a research framework adapted from Stryer et al (2000) and their study on healthcare research. We have applied this framework to our study and hope to continue using it to explore the different levels of the model. Level 1 of Figure 1 represents the exploration and reporting of problems and availabilities of new technology. Our adaptation of Level 2 represents the how that research affects a practice healthcare industry. The levels in this diagram, and the studies each level represents, build on each other to demonstrate the effects of research on an individual level all the way to a community or societal level (Stryer et al., 2000).
In this paper, literature on applications of DSS in healthcare will be reviewed and reported, according to Level 1. It is a report of the research findings in healthcare DSS broken down by all three players in the model. We hope to show questions that have not yet been answered by research in this area. It is hoped that this study can be a jumping point to move to the next level and eventually work our way, as researchers, to the top of this research model.

Figure 1. Impacts of Healthcare DSS Research, adapted from (Stryer et al., 2000)

**DECISION SUPPORT**

Decision support systems (DSS) were designed to “complement a decision maker’s ability and expertise by providing information in an efficient manner” (Hall, 2008). They assist the user in making decisions that lead to a desired state or outcome. Technology, however, is only part of the solution and should be modeled according to the unique problems within the field for which it is designed. Further, particularly in healthcare where numerous stakeholders exist, individual participation is paramount. Unfortunately, it is common for technology solutions to be developed without regard to context. Dianne Hall points out that “Despite technological advances that have allowed DSS to become more proactive and autonomous, system support is only as effective as the context in which it functions and the individuals who use it.” (2008)

Simply put, decisions are choices made from a selection of options. Decisions involve selecting an alternative or option from all available possibilities. Each potential option carries with it a different outcome or possible consequence (Holsapple, 2008). In the healthcare field, a decision could mean the difference between life and death for a patient.

To make an intelligent, informed, and correct decision, one requires knowledge relevant to the decision issue at hand. This knowledge is a collection of information, experience, and even human factors without which a decision would be impossible. A DSS selects or collects knowledge on hand or acquires new knowledge from internal and external sources and processes it in such a way that the decision maker can be more confident and informed in his or her decision. Then, the decision-making process is able to be “productive, agile, innovative, and/or reputable” (Holsapple, 2008).

DSS can be used to help operate a medical practice efficiently by organizing the staff and patients appropriately and minimizing wait time for the patient. Decision support software can help reduce medical errors and prescription errors by automatically checking the patient’s history or comparing the interactions of potential prescriptions with current medications.
(Guiseppi and Kohli, 1996, Kohli and Piontek, 2008). They can also help physicians diagnose hard-to-read symptoms by comparing them with known diseases or common symptomatic themes.

Decision systems can also be used in conjunction with intelligent agents that make decisions to organize information or present information in a certain way or at a certain time. For example, agent-based DSS can be used to handle alert medical staff members at appropriate times on a patient’s condition. A change in a patient’s heart monitor readings could automatically trigger a DSS to page that patient’s physician and notify him or her of the change. Likewise, a physician could be notified automatically when the DSS recognizes that the results of a test are complete. Systems have been developed to track and manage resources stored in tissue banks (Moreno and Garbay, 2003). This area is discussed in more detail in the next section.

DECISION SYSTEMS FOR PRACTITIONERS

Agent-based Decision Systems

Agents are computer algorithms designed to autonomously work toward a given task such as assisting in decision-making. Agents are programmed with the ability to analyze and interpret their surroundings or the data with which they are provided and make a decision or affect some outcome based on interpretation of their environment (Hall et al., 2005). Computer agents and agent-based systems have great promise in the realm of decision systems in the medical field. Agents have the capability to handle inter-facility communication, external collaboration with other medical facilities, administer the links to medical resources and databases, and provide medical training and education (Moreno and Garbay, 2003). Agents have the capability to reduce human error and improve information flow, which are critical in the healthcare industry.

Kohli and Piontek (2008) write, “Intelligent agents built within DSSs present a significant opportunity to inform decision makers about the alternatives available to them and the consequences of each alternative.” Agents can now do some of the work that physicians and technicians have done in the past. Agents can search available data to match a patient’s symptoms with possible diagnoses or provide treatment options that are similar to a current patient’s case. The backbone of such a system would be based on the linkage of different areas of the medical facility that should be working in unison to treat or assist a patient. The system would also be linked to medical databases, research facilities, and the latest treatment options. In today’s world where healthcare resources are diminished but patient loads are increasing, such a system enables healthcare providers to focus more on patient care and less on information searching.

Past research details the role automated or information agents could play in healthcare or in the administration of healthcare. A study by Rodríguez focuses on the use of agents in communication. Agents could be used to manage the communication in a medical facility or between provider locations (Rodríguez et al., 2005). Such systems could update physicians when the patient had completed their check-in and could display their symptoms or reason for visit immediately after these items were entered into the system. Allowing automated communication would reduce time for nurses and technicians to physically walk to the physician and inform them of the progress (Rodríguez et al., 2005). Automated communication could also reduce any possible miscommunication or lapse in memory due to simple human error. Medical charts would no longer be misplaced or misinterpreted due to illegible handwriting.

Another advantage of intelligent agents is that they can be programmed to monitor the progress of a patient throughout a facility. Many times patients will be seen by a physician, sent for tests, wait for the results, and then return to the physician. With appropriate technology, the progress of the patient may be tracked and test results forwarded to the physician (Rodríguez et al., 2005).

Certainly the evidence is strong for the application of intelligent agents to the healthcare industry – applying them within the context of decision support systems is the next logical step. Currently, most of the research on artificial intelligence and healthcare exists in computer-science oriented journals. It is time for IS researchers to begin the process of analyzing the usefulness, ease of use, predictability, and other aspects of this technology in its various applications. Potential questions include:

- Where is artificial intelligence appropriate and where is it not yet stable?
- Will healthcare providers be willing to receive information, and particularly advice, from such a system?
- Who in the healthcare industry can be targeted as potential experts for the purpose of populating the systems in which intelligent agents act?
- What are the security, privacy, and boundary issues surround intelligent agent systems?
Knowledge-based Decision Systems

Knowledge is very important to medical practitioners. Ideally, a physician would like to know every relevant detail about the patient’s symptoms, lifestyle, contact with others, onset of the illness, and degree to which the illness has affected them. Then, the physician would compare that information to current knowledge about existent disease and symptoms to attempt to make a diagnosis. However, a physician is unlikely to have this information available. With a knowledge-based decision-support system, the physician would have the ability to collect patient information and compare that instantly with years of medical knowledge to make a successful diagnosis (Syed Sibte Raza, 2001). Instead of having one rationally-bounded human mind considering the possibilities of the problem, there could now be an entire system dedicated to knowledge and decision-assistance. Such a system could detect inconsistencies in the patient’s information and suggest possibilities for the physician based on the information he or she collects from the patient.

Initiatives such as the Cochrane Collaboration have great promise when it comes to decision support systems in the healthcare industry. At present, the Cochrane Collaboration works to update and record information about medical trials, tests, and their results. The findings are housed in an online library. If this library could be integrated with decision support systems, the knowledge base for medical practitioners could be greatly increased, as more knowledge would be available in one place (Bero and Rennie, 1995).

These systems are already in existence, but they are segregated and often sold or implemented by different technology providers. Often the providers have contracts with limited sources of medical knowledge or a particular database, and the others are left out. This limits the potential knowledge base for the physician.

There is also the question of technology acceptance and training. The physician who may not possess the skill to appropriately use a decision support system may require more training or an easier interface. Any decision system should be very user-friendly and efficient enough to allow physicians to very quickly and easily find relevant information. This could be extremely useful if integrated with patient information. Once the patient’s symptoms are logged, agents could automatically check symptoms and patient information against possible diseases and known causes from medical databases, and the output could be automatically delivered to the physician.

Future researchers may want to investigate the following questions:

- What knowledge bases currently exist to facilitate development of KDSS?
- What standards are appropriate for a healthcare KDSS?
- What are the security, privacy, and legal issues associated with distributed knowledge systems?
- What training requirements are necessary for this type of system?

DECISION SYSTEMS FOR PATIENTS

Decision support systems can be used alleviate communication barriers between the interaction between physicians and patients. Physicians sometimes have trouble communicating with patients, finding out their symptoms, or describing treatment options. This could be because of an actual language barrier or because the patient has very little medical knowledge and thus very little understanding of what the physician is saying. Patient Decision Aids (PtDAs), using visual aids to assist in patient communication, have been shown to assist in the communication of treatment options and their potential outcomes. In fact, these PtDAs have been shown to lower decisional conflict while simultaneously increasing patient knowledge of treatments and outcomes (O’Connor et al., 2004).

PtDAs are not meant to replace the communication between a physician and a patient, only supplement it using multimedia or internet-based means (O’Connor et al., 2004). This is a decision system by a slightly different name. Using pictographic or multimedia means to communicate with patients is not unheard of, but using technologies to present treatment options visually is a newer practice. If decision systems of this nature can be used to help the patient decide upon a path of treatment, they can also be used to help physicians diagnose illness (O’Connor, 2007, Thomson and Hoffman-Goetz, 2007, Williams et al., 2008).

Patients often are unable to fully articulate symptoms to physicians. Multimedia-based decision systems could help patients make decisions on how to appropriately describe their condition. Patient DSS could ask questions to organize patients around what information a physician needs. Viewing graphical representations of the body on a computer screen and asking questions about pain or feeling might allow patients to make more informed decisions and might allow for a better quality of information provided to diagnosing physicians.
Future researchers should ask questions such as:

- Are potential benefits of PtDAs outweighed by increased technology or time necessary?
- Can PtDAs be used to facilitate the communication from patient to doctor in the way it is used for doctor to patient communication?
- Are doctors and patients both willing to interact with PtDAs?
- Do PtDAs change the relationship between provider and patient?

**DECISION SYSTEMS FOR PROVIDERS**

Decision support systems are being used in a number of applications in healthcare. The literature has documented that DSS are able to drive reminders for physicians, provide alerts for administering tests and prescriptions, interpret complex investigations or diagnoses, calculate proper drug dosage, monitor drug interactions, assist with computerized physician order entry (CPOE), and preemptively advise physicians about potential patient complications (Delaney et al., 1999, Kohli and Piontek, 2008). DSS use has also been applied to medical facility administration by assisting with medical facility administration (e.g. patient admission, waiting, and discharge) and measuring variables that affect patient complications, readmission, and mortality. DSS can also be used to assess the effectiveness of medical decisions and treatment options and measure patient satisfaction (Kohli and Piontek, 2008).

Emel Aktas proposes a management oriented decision support model to assist health system managers in improving the efficiency of their systems and processes (Aktas et al., 2007). The results of the study offer a picture of the current system and provide insight for managers into making decisions about where to allocate primary resources. Strategies with the greatest weight will appear as those having the highest impact on the overall performance of the critical variables (Aktas et al., 2007). The proposed decision support model was applied to a radiology department of a private hospital in a case study and highlighted the affected areas and processes.

Another type of DSS used by healthcare is on-line analytical processing (OLAP). It gives the decision makers the flexibility to customize the selection, aggregation, and presentation of data. Tremblay and Fuller (2007) studied the implementation of an OLAP interface on a data warehouse used by knowledge workers at a regional health planning agency in Florida. The field study showed that healthcare workers utilized the additional capabilities of OLAP (e.g. aggregation levels and intuitive data manipulation), allowing them to leverage their individual abilities to enhance and expand on the tasks they performed for the agency (Tremblay et al., 2007).

Isabel is the name of a diagnostic decision support and knowledge mobilizing system designed to aid the clinician in considering all the likely diagnoses and to make the latest medical information readily available at the point of care. The healthcare providers may already have anecdotal evidence, but using a DSS based reporting solution allows them to validate their ideas and move towards more evidence based solutions (Lamont, 2007).

DSS for prescribing medication have proven successful in the healthcare industry. It has been shown that unaided physicians are extremely cautious in estimating drug dose. DSS aided dosages tended to provide higher doses, but no studies or systems reported an increase in unwanted side effects (Walton et al., 1999). The research suggests that DSS for prescription dosage helped physicians tailor drug doses more accurately to individual patients. Patients treated with computer supported dosage experienced less pain and had better recovery, fewer errors were made, and physicians and nurses embraced the systems (Walton et al., 1999).

DSS should provide a solution to the physician at the same level of performance as a human expert, use symbolic and heuristic reasoning rather than numeric and algorithm procedures, and provide detailed explanations of their reasoning (Delaney et al., 1999). Clinical decision support (CDS) systems provide clinicians, staff, and patients with knowledge and person-specific information intelligently filtered and presented at appropriate times, to enhance healthcare (Osheroff et al., 2006). CDS has been somewhat successful in the healthcare industry at some specific locations and practice sites, but it has become problematic and stalled in the planning stages at many locations. These delays have prevented relevant medical knowledge from being used in important healthcare decisions and have the potential to adversely affect patients (Osheroff et al., 2006).

Limitations in healthcare funding require hospitals to find more effective methods and procedures to utilize scarce resources. One of the basic problems of healthcare managers is making good decisions for quality patient care while dealing with the pressures of cost control. Decisions often have to be made with incomplete or imprecise information. An effective patient management system is critically dependant on the accurate analysis of individual patient outcomes and resource utilization.
DSS provide readily available references and allow access to knowledge that is specifically pertinent to the patient case, improve the clarity of information and possible diagnosis, can be tailored to specific patient symptoms and characteristics, and provide decision support information in a more timely manner (Sullivan and Wyatt, 2005).

Even though DSS for healthcare has great potential, studies still show there is difficulty in implementing and advocating use of the system that is put in place. Too often the current clinical processes take precedence over utilizing the DSS. Many studies that analyze the impact of DSS on healthcare have severe limitations and lack generalizability (Eccles et al., 2002). Eccles, et al, found that computerized DSS had no significant effect on consultation rates, process of care measures, or any patient-recorded outcomes for their condition. They also found low levels of use of the system by clinicians, even though the system was designed for clinician use (Eccles et al., 2002). Other researchers found failure reasons included not ensuring users understood the reasons for implementation and underestimating the complexity of healthcare tasks (Littlejohns et al., 2003). Managing the organizational and human resource change is just as important as the technical aspect. If the people are not on-board, the DSS is bound to fail from the outset.

DSS were also studied with cardiovascular patients. Research was performed on 27 general practices covering 614 patients. The results were that computer based clinical DSS and chart only groups were no more likely to have cardiovascular risk reduced to below 10 percent than patients receiving usual care (Montgomery et al., 2000). The DSS showed no significant improvement in patient care over current practices.

Another reason for potential failure of a DSS is that patients and medical professionals are sometimes hesitant about trusting information to electronic means as well as trusting software packages and, particularly, information agents to make decisions for them. Vazquez-Salceda (2005) writes, “such technologies should become comprehensible, safe and sound in order to increase the trust of patients and practitioners.” Though agents probably make decisions for practitioners every day, the thought of turning over basic management of a medical facility to a system or software package may to some seem terrifying. However, the technology is readily available and capable right now, and it could certainly improve the efficiency and potentially reduce costs for medical facilities.

There is also research that debates the validity of the knowledge bases and the ability of the decision support systems. The research regarding the validity and structure of the Cochrane Collaboration, for example, seems to be greatly debated in the literature (Clarke, 2007, Clarke et al., 2008, El Dib et al., 2007, Hotelling, 2007, Kingdon and Lavender, 2008). Empowering decisions in the healthcare industry with more knowledge certainly has value. The research in this area is promising, but more research should be done to determine validity and dependability on knowledge bases. Then, research and testing should be focused on developing a more reliable and valid DSS.

Researchers also discuss whether or not physicians and medical staff would require more education and training to use such resources. Researchers seem to agree that there would have to be ongoing education as technology advanced and that more time would have to be spent on such technology in medical schools worldwide, should that technology become a standard (Jadad, 2000). With current technology trends what they are not only in the healthcare field but in every aspect of daily life, this conclusion is undeniable and inevitable.

Researchers may wish to consider the following:

- Would medical practitioners prefer an over-arching decision system (similar to ERP) or something less intrusive to their current practices?
- What are the readily available technology options that are attempting to integrate the different aspects of decision support in the medical field?
- What are the non-monetary costs and risks involved in implementing a DSS?
- What effect does trust or familiarity with “IT” have on decision support system acceptance?
- To what degree would medical practitioners be willing to release “control” over their practice or facility to allow agents or DSS to automate decisions and allow for more efficient management practices?
- Would obligations to the patient overrule any attempt by medical staff to oppose or undermine an implementation of new systems?
- What effect does organization size have on technology acceptance?
FUTURE RESEARCH

A literature review of the existing research in healthcare DSS seems to have brought up perhaps as many questions as it has answered. It is apparent that DSS are being studied in the healthcare industry and existing DSS literature and documentation is being applied to the study of healthcare-specific DSS. However, we are very interested in the impact of the research on actual implementations and policies in the healthcare industry.

As in Figure 1, we feel that a majority of the research is simply reporting findings, or at Level 1. This paper has been mainly a “state of the research” in this area. As a next step in this research stream, we hope to get some feel for the “state of the technology” in the industry and at least help answer the question where are healthcare providers, as far as using, implementing, or planning to implement DSS technology. This would fall into Level 2 of our research framework.

This study, combined with other studies could lead to a transformation of health policies and procedures, a creation of standardization for the industry to use DSS that would eventually affect the overall healthcare of society as a whole.

CONCLUSION

Kohli and Piontek (2008) write, “The era when the physician knew best is evolving into an era where the physician knows where to find the best information.” We find this to be very true. It is clear that the role of information technology is growing exponentially in the healthcare industry. It is also evident that healthcare is not going out of business, with new diseases and illnesses being discovered every day. Medical facilities inevitably will have to find ways to treat more patients in more creative ways, and technology can provide ways to allow them to do so more efficiently and have more information at their disposal.

The role of decision systems in the healthcare industry today seems to be oriented around improving medical care while at the same time reducing cost and increasing efficiency of medical practitioners (Kohli and Piontek, 2008). It follows that if medical practitioners are able to do their jobs more efficiently they should be able to treat more patients and should be able to provide a better standard of care.

More research must be done on the role of DSS in the healthcare industry. This research cannot be purely theoretical; it must involve case studies of medical facilities and trials (and failures) of DSS systems. There is also missing research when it comes to costs and potential costs reduction. Before medical practitioners will implement a DSS, it can of course be assumed that these issues will be questioned. This technology is certainly promising for the healthcare industry, but it is up to us as researchers to assist the healthcare industry in discovering its full potential.

Much work is yet to be done in a field that promises to yield extensive benefits to all stakeholders in the healthcare industry. This work has taken a much needed step toward organizing healthcare decision support issues and identifying potential research questions but is not exhaustive. Many avenues are still uncharted, and we encourage researchers to use it as a basis for formulating the next generate of healthcare DSS research.
REFERENCES