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Healthcare Information Systems: Opportunities and Challenges

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INTRODUCTION

The prognosis for successful healthcare information systems (HIS) implementation is really great. It is expected to increase legibility, reduce medical errors, shrink costs and boost the quality of healthcare (Jha et al., 2010; Blumenthal & Tavenner, 2010). Healthcare information technology (HIT) implementers and promoters continue to espouse these benefits as opportunities for the transformation of the healthcare sector. Nevertheless, the journey to this ideal is fraught with challenges. These challenges range from issues arising from the very nature of healthcare information, to the issues pertaining to healthcare information technology and its users.

This chapter discusses the opportunities and challenges that lie within healthcare information technology and systems as a whole. In the proceeding sections, the following themes are examined more closely: a quick view of the evolution of HIS and current trends, opportunities and challenges within HIS, and finally, some lessons learned are discussed. These themes relate issues that touch HIT standards and stardardization, electronic health records, healthcare technology adoption and implementation, resistance to healthcare technology, policy issues, and privacy/security.

There exists a potential for healthcare information systems to significantly increase the overall quality of health (Blumenthal & Tavenner, 2010). This is evidenced by the investments that are currently being pumped into the HIT development and adoption (Blumenthal & Tavenner, 2010; Department of Health and Human Services, 2010). Nevertheless, for HIS to deliver its promise, there are significant hurdles that must be dealt with stemming from the interaction of HIT system users, HIT itself and the policies that regulate healthcare information systems use.

BACKGROUND

Healthcare information systems refers to such systems that are used to process data, information and knowledge in healthcare environments (Haux, Winter, Ammenwerth, & Brigl, 2004). While healthcare information systems and health information systems are often used today to refer to the same concept, a series of terms have been used in the evolution of this phenomenon from its early foundations in the 1960s. Though there is no clear consensus in literature until lately, the term *health information systems* is analogous to various primitive forms of this concept such as hospital information systems. Similarly, terms such as *computerized patient records*, *electronic medical records*, and the more current *electronic health records* have come to be commonly used almost interchangeably. Though the exact meanings may differ, all represent a progression in the development of healthcare information technology. Haux (2006) discusses major evolutionary developments from the primitive *hospital information systems* to the *health information systems* as we know them to date. In the following paragraphs important trends are discussed in a bid to provide a perspective to this chapter.

- **Trend 1: From Paper-Based Systems to Computer-Based Systems:** Meanwhile health data and information in the past have been created and stored mainly on paper, there has been a clear migration from paper to computer-based systems (Haux et al., 2002). This ability means that more data can be processed and stored through the use of modern information technologies to yield better knowledge. The future of healthcare information systems looks towards a near "paperless" era.

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- **Trend 2: From Local to Global Information Systems:** While earlier healthcare information systems were limited to departmental units (e.g. radiology, or laboratory) or just within a healthcare practice system (e.g. hospital or clinic) (Linberg, 1968), modern healthcare systems target regional, national and even a global reach.
- **Trend 3: From Healthcare Professionals to Patients and Consumers:** Originally, healthcare information systems were designed to be used by mainly physicians and administrative staff (Ball, 1971; Ball et al., 1994), but it was later passed on to be used by nurses. Since then, the trend has shifted to involve more patient input.
- **Trend 4: From Using Data for Patient Care to Research:** Over the years, patient data has been used beyond patient care management to a more general use involving research in healthcare (Leiner, Haus, Haux, & Knaup, 2002; Kuhn & Guise, 2001) and even education.
- **Trend 5: From Technical to Strategic Information Management Orientation:** Haux (2006) has noted that while computer-supported information systems from the 1960s to the 1990s focused on problems resulting from the technical aspects of the systems, concerns about the organizational problems, social issues and change management aspects became more relevant at the turn of the millennium.
- **Trend 6: From Numeric Data to More Complex Forms of Data:** Not only has the technology that support *health information systems* advanced in technological complexity, the data that is being received and processed has also become complex. From numeric data through alphanumeric data to imaging and even molecular data (Maojo & Martin-Sanchez, 2004).

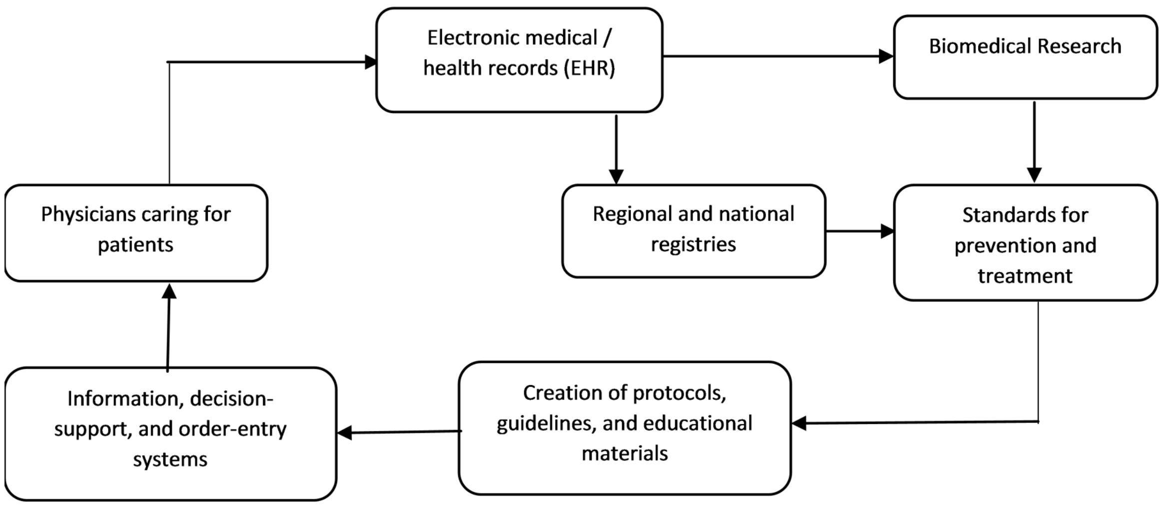
Health Information Systems Infrastructure and Information Flows

Health information technology consists of a wide range of networking technologies, clinical databases, electronic medical/health records, and other specific biomedical, administrative and financial technologies that generate, transmit and store healthcare information. In the diagram below, a generic model of information flows that typify health information systems infrastructure is presented, and a brief discussion of the application of this model is highlighted in Figure 1.

In the model above, all information from healthcare providers (hospitals, clinics, emergency rooms, small offices, multispecialty groups, etc.) are entered into an electronic health record. This information is then networked to regional and national databases through electronic exchange. Data flows from EHRs and regional registries are then channeled into standards for prevention and treatment, which can be further processed to yield information for decision-making and decision-support. At each of these levels, appropriate information technologies are used to undergird data flow. The implications of this type of technological architecture are many-fold. First, it raises issues of the encryption of data. The United States Health Insurance Portability Accountability Act (HIPAA) has set in place the privacy and security policies to provide guidance. Second, the standards for data transmission and sharing over networks requires that all EHR developers all use the same standard—the HL7 standard. Third, given data transmission standards, data definition standards are equally important. They ensure that data communicated is read and understood by others. Fourth, with data coming from diverse healthcare sources, data quality control then becomes critical. Lastly, this model infrastructure means that regional and national databases with ability to hold, manipulate and produce useful information for decision-making.

Shortliffe and Sondik (2006) discuss a practical application of a health information system like the one above in cancer information surveillance. In this example, information from EHRs are processed and used in a manner that improves cancer-related decision-making to bring about an improved quality care for cancer patients. Hence, using health information technology to monitor, manage and control cancer care.

Figure 1. Information flows in a health information systems (Adapted from Shortliffe & Sondik, 2006)



Summarily, the healthcare information systems arena has changed and is changing. These changes offer unique opportunities as well as challenges never before seen. Whether opportunities or challenges, both of these phenomena cut through technological, organizational and human factors. In fact, the interaction between these factors are responsible for providing a more informative and rich lens for understanding the current and future landscape of health information systems. Like Shortliffe and Sondik (2006) have stated, the potential barriers in healthcare information technology are rather logistical, political and financial than technical. Hence, in the pages below, an effort is made to discuss these factors in the light of the both the opportunities and challenges that be. The rest of this paper is dedicated to discussing the opportunities and challenges that lie in HIS arising from the triad interaction of technology, the internal and external environments of the healthcare sector, and the human agent.

OPPORTUNITIES

Healthcare information systems have been critically acclaimed for their ability to increase legibility, reduce medical errors, shrink costs and boost the quality of healthcare (Jha et al., 2010; Blumenthal & Tavenner, 2010). In the following subsections, the potential opportunities that lie in HIS are examined.

Cost Savings

Healthcare information systems is expected to save money in the long run and generate organizational profitability through efficiencies, cost-effectiveness and safety of medical deliveries (Devaraj & Kohli, 2006; Goldsweig, Towfigh, Magloine, & Shekelle, 2009). Practically-speaking, it is expected that HIS will reduce expenses associated with record-keeping while meeting privacy regulation standards and improving workflows, practice management and billing. HIS is also expected to permit automated sharing of information among providers, reduce office visits (to receive tests results) and hospital admissions (due to missing information), and even reduce risks of malpractice law suits (Goldschmidt, 2005)

Devaraj and Kohli (2000) have found that information technology (IT) investments in the healthcare industry leads to increased profitability and quality products and services. Hillestad et al. (2005) argued that the United States healthcare industry was probably the most inefficient information enterprise in the world. They further contended that more than $81 billion could be saved annually if electronic medical record (EMR) systems were effectively and sufficiently implemented. With the adoption and implementation on interoperable EMR systems they were even more optimistic, estimating a cumulative net savings totaling another $142-$371 billion over a 15-year period. There seems to be no question that long-term savings is a potential economic strength of health IT systems.

Reduction in Medical Errors

The Institute of Medicine (IOM) (1999) study reported that up to 98,000 people die in U.S. hospitals each year as a result of preventable medical errors alone. It further predicted that 50% of errors could be eliminated over a five-year period if existing technological know-how was implemented. A more recent report noted yearly increases in medical errors—claiming a disturbing 1.5 million adverse drug events due to preventable medical errors (Institute of Medicine, 2006). In its list of solutions to this problem, the IOM unequivocally mentioned the use of health information technologies—such as e-prescription—as a key solution element. Evidently, health information systems' role in increasing legibility and medical error reduction in healthcare services has been shown to be a potential benefit.

Overall Quality of Healthcare

While reduction in errors certainly contributes to the quality of healthcare, there are more general opportunities that HIS offer. Goldschmidt (2005) and Van de Castle et al. (2004) provide insights as to how HIS contribute to improve overall quality of care and patient outcomes in a population. These include:

- More complete, accurate and structured clinical data documentation;
- Automatic sorting and summarization of data for information generation;
- Direct access to instant updates to records as well as remote access to patient records;
- Reduced medical mistakes from legibility and order entry errors;
- Increased decision support from structured data and predictive modeling and disease management tools;
- Data mining capabilities provided by the vast amounts of structured medical record data contributing to disease research and preventive interventions in clinical care; and
- Continuous improvement in clinical decision making through decision support (enabled by health information exchange), rapid dissemination of information and quicker monitoring of care.

Through the aforementioned capabilities of HIS, mistakes are kept at bay, information quality is enhanced, treatment response times are improved, and optimal decision-making is attained.

CHALLENGES

In spite of the huge potential and opportunities that lie in HIS to radically transform healthcare and the healthcare sector, many challenges are evident and imminent. The adoption of IT in healthcare has been particularly slow and lagging behind that of major industries by as much as 10-15 years (Goldschmidt, 2005). This is further exacerbated by the failure in HIS implementation as well as resistance to the use of the technology by healthcare professionals (Berg, 2001; Heeks, 2006; Anderson, 1997).

These challenges range from issues related to the technology itself, the healthcare setting, system users and the regulatory environment. For instance, Blumenthal (2009) lists the barriers faced by healthcare information technology proponents in the U.S. namely: low adoption rates by doctors and hospitals due to associated costs, perceived lack of return on investments, use issues and concerns of privacy and security.

Generally-speaking, challenges stem from the interaction of technical, human, and organizational factors affecting the adoption and use of these healthcare systems. To better explain these factors in their proper contexts, I shall use the "design-reality gap" proposed by Heeks (2006). This model was originally conceived to be used to measure health information systems failure both as a *post hoc* evaluative tool and a *pre hoc* risk mitigation assessment. In this section, however, this framework is used to better explain the nature of HIS challenges within the healthcare sector as well as the environmental factors that impact it.

According to Heeks (2006), the success/failure of an HIS is contingent on the gap between "design conceptions of HIS" and the "current realities." This paradigm argues that the two major stakeholders of HIS, namely system designers and the system users both possess their different but subjective versions of reality. Furthermore, because these groups are especially valuable to, and different from each other, their interaction produces the challenges that HIS faces.

More specifically, the "design-gap" framework provides a lens for pitching HIS designers' view of the technology and its context, versus HIS end-users' view of the same technology. Based on this, the "design-reality" gap paradigm presents three archetypes of hard-soft gaps that are crucial to understanding healthcare challenges. These archetypes are technical rationality, managerial rationality and medical rationality.

Technical rationality: Technical rationality depicts a technology-based worldview where everything is supposed to be objective and rational—not subject to personal, cultural, and political influences. Designers of HIS technology are typically dominated by IT professionals with this kind of mindset. They design a system with the view that is would be looked upon rationally and objectively. Hence, they emphasize on the specifications and the technical designs that will yield particular outcomes.

Nevertheless, technical challenges still arise from lack of standardization of technology, the absence of a well-developed healthcare information exchange (HIE) which will permit healthcare institutions in a given region to be able to freely share healthcare data. The ability to have an interoperable health information exchange that can both share information quickly and seamlessly also raises concerns on privacy and security of electronically transmitted data (Blumenthal, 2009). Walker et al. (2005) have estimated that fully standardized HIEs could yield a net gain value of $77.8 billion a year if fully implemented. We observe therefore that, even though these systems are mostly built from a technical worldview point, issues on usability, standardization and interoperability further exacerbate the problem.

Managerial rationality: A managerial worldview of HIS emphasizes the economic and socio-political outlook of systems. Typically, managers are concerned about the costs, return on investments, and even the interest of external stakeholders like the government. They perceive the system from the standpoint of the surrounding socio-political and economic system within which the technology is supposed to be embedded. Like technology, money is usually considered as a rational entity. When financial information is perceived to have a role in HIS, those information systems are likely to be viewed through an objective and rational model. This is particularly true when a finance-based worldview dominates design inscriptions.

HIS direct and indirect costs remain a major concern of many healthcare institutions. This is particularly so, because of the high initial investments and the low perceived return on investments (Anderson et al. 2006; Blumenthal, 2009). As Devaraj and Kohli (2000) have also noted, business process re-engineering is also a difficult issue to handle. Most changes that come with HIS implementation require huge organizational changes requiring not only financial investments but a total change in the way business is conducted. Lastly, there exists an interdependence between financial and clinical outcomes that dictates to a reasonable extent how much investment should be made to achieve a particular health outcome. Hence, cost of acquisition, running and maintenance of HIS is still a veritable barrier.

Medical rationality: Though this dimension focuses primarily on medical personnel, it is also considered in an objective and rational sense when diseases and injuries (but not patients) are the focal entity. When medical information is seen to play a central role in HIS, these information systems are therefore themselves likely to be conceived according to an objective and rational model. This would be the case in a design where clinicians or other healthcare professionals dominate the design process causing a medicine-based worldview to prevail in design inscriptions.

Medical rationality is likely to explain the wide and massive resistance to HIS since its inception. Physicians and other healthcare personnel view the system from an entirely different paradigm than IT personnel or managers. In a study of twenty IT and IT-related journals over the past 25 years, Lapointe and Rivard (2005) found that 43 articles identified resistance as a key implementation issue. They also noted that though these articles acknowledged the importance of the study of user resistance to IT. Researchers in IT resistance point to the role of *perceived threats* and *perceived inequities* as part of the cause of some the resistance to HIS by healthcare professionals (Bhattacherjee & Hikmet, 2007; Lin, Lin, & Roan, 2012). Research in the area of end-user resistance to information technology is clearly rising, but researchers will need to know *how* and *why* resistance to information systems occurs, especially in HIS environment. Additionally, training of dedicated health personnel to support HIS implementation and meet the standards of anticipated healthcare outcomes is critical. Hence, a clear challenge in HIS adoption is end-user resistance to the systems, as well as the lack of dedicated practitioners.

FUTURE RESEARCH DIRECTIONS

Health information systems implementations have so far registered their fair share of failures (Heeks, 2006). Nevertheless, the need for *health information technology* that reduces medical errors, cuts costs and improves the overall quality of healthcare has never been greater. And, though the challenges are many, there is much that can be learned from HIS evolution beginning from its primitive roots in the 1960s and from a relatively older and more established sister-technology like enterprise resource planning systems.

The path to a fully integrated healthcare information system is truly a journey and not a destination (McDonald et al., 2004). However, the call for improved systems requires that we draw lessons from the past to set an agenda for the future. In this section, I draw from Berg's (2001) myths about information systems implementation to propose some future research directions.

1. **HIS implementation research should adopt the view that systems implementation is more than the realization of a planned technical project within an organization:** From the history of failures of systems implementation, there seems to be a prevailing assumption by systems implementers and their sponsors that the technology will change organization in unprecedented ways. This usually is true to an extent. Nevertheless, only part of the story is told by this perspective because organizations do not interact with technology in a completely inert fashion. Since HIS technology affects the organization's structures and work routines in significant ways, this characteristic in itself can be the reason why these systems fail (Lorenzi & Riley, 1995). When technology confronts organizational routines, workflows and culture; the organization naturally confronts the technology. In this confrontation, there is usually give-and-take reaction during which the technology changes the organization, and at the same time, the organization begins to transforming the technology. This has huge implications for HIS implementation namely that, implementers and change managers must be open and prepared to make changes in the technology just as much as they anticipate the changes in the organization. Researchers and practitioners should therefore consider this view.
2. **HIS implementation research should recognize and respond to a *contextual view of implementation*:** By limiting system implementation to the "IT department," many organizations have awoken to the rude awakening of implementation failures. The role of IS in an organization must always be understood in context. Information technology is an enabler of change; and is implemented in an organization as a catalyst of sociotechnical change. Therefore, technology being introduced in an organization cannot be looked upon as a "mere technical project" (Berg, 2001). With this understanding therefore, HIS implementation should be run with a project team where all stakeholders (especially system end-users) are involved from the start to finish including top management. User-involvement in HIS implementation must go from just being a good slogan, to a seriously thought-through-and-followed-through strategy for achieving IS implementation success. Future research must recognize it thus.
3. **HIS implementation research should view organizational redesign as a process that cannot be completely planned and totally controlled:** Again, information technology is expected to impact an organization in much the same way that the organization itself might influence the technology. Meanwhile implementation and organizational redesign must be anticipated and planned, implementers must remain open for the unexpected and use irregularities as a feedback mechanism either to change technology or the organization, or both. However, implementers must also keep in mind that the "core business" of the healthcare industry is not the "internal business" but rather primary care processes

that these organizations exist for in order to optimize effectiveness and efficiency (Davenport, 1993). Hence, all implementation and redesign processes must finally reflect a strategic effort to better serve the patient and not the implementer, or the healthcare professional.

4. **HIS research should adopt a multidisciplinary approach:** Healthcare information systems challenges have generated several research questions that could probably only be handled from a multidisciplinary platform. Chiasson, Reddy Kaplan and Davidson (2007) have called on information systems and medical informatics disciplines to draw from each other methodologically and theoretically. Such quality research will serve to guide practice. Additionally, such findings and recommendations can also be factored into information systems and medical informatics curricula that could help the achievement of desired outcomes.

CONCLUSION

Healthcare information systems promises to increase legibility, reduce medical errors, shrink costs and boost the overall quality of healthcare (Jha et al., 2010; Blumenthal & Tavenner, 2010). Government investments in healthcare technology are both significant and purposeful in achieving desired outcomes (Anderson et al., 2006). Nevertheless, there are many challenges resulting from the technology, end-users and environment that continue to undermine these efforts. This article explored the opportunities and challenges that lie in health information systems and lessons learned were also highlighted. Future implementation will do well to focus on the integration of all stakeholders and technology while remaining mindful of the socio-cultural organizational environment while exploiting recent advances in cloud technologies and information exchanges.

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KEY TERMS AND DEFINITIONS

H

Computerized Physician Order Entry (CPOE): A health information technology that allow for the use of computer assistance to directly enter medication orders from a computer or mobile device. This order is also documented or captured in a digital, structured, and computable format for use in improving safety and organization.

Electronic Medical Records (EMR) / Electronic Health Records (EMR): An HIT that enables the storage, modification, retrieval and transfer of health information of a patient in a manner that supports and improves the patient's overall quality of health while providing decision support for the healthcare professional. When the technology is used with a health practice, it is known as an EMR; but when records are shared with other health entities beyond the primary care institution, it is referred to as EHR.

Enterprise Resource Planning ERP: An integrated computer-based system used to manage a business's internal and external resources, including tangible assets, financial resources, materials, and human resources. It supports all applications across business units.

Healthcare Information Exchange (HIE): The mobilization of healthcare information electronically across organizations within a region, community or hospital system.

Healthcare Information Systems (HIS): An integrated effort to collect, process, report and use health information and knowledge to support decision-making that affects individual and public health outcomes as well as policy and research.

Healthcare Information Technology (HIT): A wide range of products and services—including software, hardware and infrastructure—designed to collect, store and exchange patient data throughout the clinical practice of medicine.

Meaningful Use Policy*:* **A U.S. Department of Health and Human Services policy that requires health professionals to use certified electronic health record (EHR) technology to improve quality:** safety, efficiency, and reduce health disparities, engage patients and family, improve care coordination, and population and public health while maintaining privacy and security of patient health information.