Abstract

This is a time of expansion, hope, and change in the area of health information technology (HIT). In this study, we provide an in-depth perspective into the adoption and diffusion of IT in Health Care based on a review of the current literature and upon expert panel assessments of adoption and diffusion issues, achievements to date, challenges facing key e-health technologies, and future possibilities. This data is synthesized in the form of a research framework showing the main three areas of e-health (Electronic Medical Records, Clinical and Administrative systems, and Telehealth) on three levels (individual, organization, system). Current adoption and diffusion challenges and future possibilities are systematically presented via this research framework to inspire practice and research with both an individual and collective view of the key health systems currently confronting the health care sector.

1. Introduction

“If well funded and adopted widely, many different technologies--from electronic records to algorithms to remote monitoring devices--promise to streamline the health care system, saving money and improving services” (Ruiz, 2008). The vision of modern health technologies to even partially reach the status of “modern penicillin” to improve health care quality, access, and cost improvements across the globe is contingent on adoption and diffusion. Health care is, by nature, a system that intertwines many individuals, organizations, and government policy. Technology adoption and diffusion depends on each of these levels. Unfortunately, the complexities and challenges at each individual level as well as the related connections among the levels blur the vision. But just how blurry is it?

We know of no recent studies in the field of information systems that collectively assess key health IT systems with a futuristic perspective by aggregating up-to-date research with insight from practice using an organized framework. This study seeks to fill this void. In this study, we provide an in-depth perspective into the adoption and diffusion of IT in health care based upon a review of the most currently available literature and upon expert panel assessments of adoption and diffusion issues, achievements to date, challenges facing key e-health technologies, and future possibilities.

Our overall research question is: How can we integrate Health Information Technology? Our hope, in essence, is to provide a corrective “lens” for the blurry vision. The data and conclusions will not solve the problems, but can provide clarity to facilitate moving in the right direction.
We attend to this purpose via 1) a multidimensional review primarily consisting of papers accepted over the past seven years at arguably the most noted minitrack conference focused on IT Adoption, Implementation, Diffusion, and Evaluation in Health Care Information systems at HICSS and 2) by directly consulting practice by way of an expert panel.

The next section introduces the research framework and context of the study. From there, we provide the result of our literature review followed by the results of our expert panel. Our discussion section synthesizes the findings through the lens of our research framework. We then provide conclusions noting limitations of this study and highlighting opportunities for future work.

2. Research Framework

This study uses an adapted framework proposed by Spil et al., (2009) (see table 1) as a framework for discussing and synthesizing e-Health challenges and prospects. This framework acknowledges three levels of discussion in the literature regarding the aforementioned systems: 1) the individual level; 2) the organizational level; and 3) the systems level. The model also acknowledges the overlap among these three levels of inquiry and analysis.

Table 1 E-Health Research Framework (adapted from Spil et al, 2009)

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<th>LEVEL/APPLICATION</th>
<th>EMR</th>
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To properly understand this framework and its use in this study, it is important to clarify our meaning of each term and set the stage for our further inquiry. We begin with the term, e-health. We will use the generic, more practical term “e-health” throughout this paper in reference to health information technology and its application. “E-health” represents the broad array of electronic systems and applications that are used in today’s technologically advanced health systems. “E-health” is not just the technology but the “leveraging of the information and communication technology (ICT) to connect provider and patients and governments; to educate and inform health care professionals, managers and consumers; to
stimulate innovation in care delivery and health system management; and, to improve our health care system” (Oh et al., 2005). More specifically, however, in this work, we use the term e-health to address the three technologies that form the core of e-health (Electronic Medical Records - EMR, Clinical and Administrative systems, and Telehealth) on three levels (individual, group/organization, and systems/national).

The terms, Electronic Medical Record (EMR), Electronic Patient Record (EPR), and Electronic Health Record (EHR) are often used interchangeably, yet we need to point out that, technically, there is a difference among them. EMR is the active tool used by providers that provides access to patient records and information, decision support, resources, and alerts. EPR contains patient health related information gathered across at least two health organizations. Finally, EHR includes wellness information and information that is not routinely collected or kept by health facilities, and may or may not extend beyond one organization. For our purposes, we assume that regardless of EHR, EMR, or EPR, the system being discussed has the capability to provide clinical decision support, support physician order entry, capture and query information relevant to healthcare quality, and exchange electronic information with, and integrate such information from, other sources (Wilson, 2009). A wide array of clinical and administrative benefits has been anticipated with the adoption of Electronic Medical Records. These benefits include, but are not limited to: appropriate information to guide medical decisions, improvement of healthcare quality, reduction of medical errors, delivery of appropriate and evidence-based care, reduced healthcare costs, increased efficiency, improved coordination of care, and information sharing. Despite these projected benefits, many questions still remain regarding the adoption and use of EMR: What are the reasons for clinicians’ slow acceptance and use? Does EMR actually deliver on the efficiency and cost savings that are prophesized for organizations? Will EMR truly increase the quality of healthcare?

Other clinical systems consist of components that make the EMR more complete. Without inputs to the system of reports typically received by the primary physician, such as imaging and laboratory, documentation supporting the decisions by clinicians is incomplete. As health care information systems move toward increased interoperability and portable patient records, the composition of the EMR must consist of a wide range of information regarding any specific patient. Information from corresponding systems such as imaging and laboratory resources can be merged into the patient record. These are essentially services ordered by primary clinicians, and decidedly belong with the EMR. To achieve a complete system, other clinician orders, such as medications, should also be components of a
comprehensive medical record system. We investigate issues with these specific "other clinical" systems that will need to be incorporated to achieve a comprehensive EMR.

Telemedicine is defined as “the use of medical information exchanged from one site to another via electronic communications for the health and education of the patient or healthcare provider and for the purpose of improving patient care. Telemedicine includes consultative, diagnostic, and treatment services (Dictionary, 2008). Telemedicine is one service that healthcare organizations provide with the help of collaboration technologies (such as video conferencing) to bridge locations within or among health care organizations. Telemedicine has been stated to have “the potential for ameliorating seemingly intractable problems in healthcare such as limited access to care among segments in the population—especially the geographically disadvantaged—uneven quality of care, and cost inflation” (Bashshur, 1995). Though multiple telemedicine programs have shown to be clinically effective, it does not seem this potential has not yet reached the level of mass adoption and diffusion required to attain these goals. However, it does appear that the use of telecommunications is on the rise in healthcare (Spil et al., 2009). While it appears that the use of telecommunications is increasing in healthcare (Spil et al., 2009), the important question remains, what is the overall impact of traditional telemedicine media and emerging devices such as mobile phones and hand-held instruments on quality, access and cost?

3. Literature Review

We primarily focus our literature review on the Hawaii International Conference on System Sciences (HICSS) - IT Adoption, Implementation, Use and Evaluation in Healthcare mini-track within the Information Technology in Health Care (ITHC) track. Per online search and review of the agendas and programs from major IT general conferences and targeted meetings since 2000, the IT Adoption, Implementation, Use and Evaluation mini-track appears to be the longest running consistent track dedicated to this focused topic in the field of information systems. It continually attracts authors and other participants from around the world and is noted for the quality of accepted papers. It is historically focused on the information systems community, but does attract representation from practice and authors from related fields. One or more of this paper’s authors participated in the presentations and ensuing discussions of all the papers reviewed as part of the current study. Thus, the authors of this paper have not only individually or collectively read each paper, but have dialoged

1 This track has undergone some minor name changes over the years.
with authors and seen the various reactions and spontaneous thought generated by these works. Therefore, this review is a reflection and interpretation of not only what was written, but also of what was said and discussed among participants. We readily admit there are some limitations in exclusion with the approach chosen for this study. However, this novel lens of using the continuity of the forum from a long standing, respected conference for full papers dedicated to this targeted topic may yield insight into early trends that other methods may not.

Another reason for this approach, given our purpose, is timing. Research regarding author experiences with the IS journal review process indicates that the publication cycle, particularly of high ranking information systems journals, can span multiple years (Bhattacharjee et al., 2004). It is of note that many, if not most of the papers submitted to the aforementioned track have evolved into papers published in recognized journals. Given our desire for currency in thought, a focus on adoption and diffusion from those well situated in this interest area, and an information systems perspective, we chose to closely canvass recent year’s accepted submissions to the mini-track as the foundation for the literature review.

As a first step to providing illuminating adoption and diffusion issues, achievements to date, challenges facing key e-health technologies, and future possibilities we look to literature focused on this topic. We supplement the mini-track conference paper review with refereed journal publications, as needed, to gain a more in-depth perspective on issues raised regarding the adoption and evaluation of IT in Health Care. We use this literature review to provide the context for data collection from an expert panel regarding future adoption and evaluation concerns.

3.1 Electronic Medical Record Systems

EMR: Individual Level:
Provider acceptance and barriers to use literature may be best discussed in reference to the most common theories used in EMR individual research to date. TAM, the Technology Acceptance Model, is an information systems theory that models how users come to accept and use technology: the main dependent constructs are Behavior Intention to Use and System Usage. The model suggests that when users are presented with a new technology, two factors influence their decision about how and when they will use it: Perceived usefulness and Perceived ease of use. TAM assumes that “when someone forms an intention to act, that they will be free to act without limitation” (Bagozzi et al., 1992).
The Unified Theory of Acceptance and Use of Technology (UTAUT) is a comprehensive synthesis of TAM that is non-healthcare specific, yet serves as a useful, theoretical lens regarding strategic implementation and adoption of EMR. UTAUT proposes a set of variables that directly influence the outcome variables of Behavioral Intent and Usage of Technology. The theory holds that four independent constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions) are direct determinants of usage intention and behavior (Venkatesh et al., 2003). In addition, each of the direct determinants is mediated by one or more of a set of demographic variables such as, gender, age, experience, and voluntariness of use.

Yarbrough and Smith’s (2007), comprehensive review of TAM-based health information technology (HIT) literature found the interruption of traditional practice patterns, lack of evidence regarding benefits of HIT, organizational issues, and system-specific issues as barriers to physician’s adoption of HIT. A study of 55 British physicians found time and cost as barriers (Horsley and Forster, 2005). Karsh et al., (2006) found system non-fit with practice patterns, organizational issues of confidentiality, error reporting, and physician time costs as primary barriers to physician adoption and use of EHR. Pare, Sicotte, and Jacques (2006) suggest that perceived usefulness and a construct noted as “psychological ownership,” to positively influence technology acceptance. Perceived ease of use effects perceived usefulness, but not the intention to use HIT (Yi et al., 2006).

Using UTAUT as their theory base, Wiggins et al., (2009) explored the influence of medical education and training on the intentions of family practice residents and their instructors, to actively seek or avoid joining practices where an EMR system is used. Both formal training and assistance by fellow residents were seen as methods of making the system easier to use, but had no impact on the intent to join or avoid practices using EMR. Prior work by Trimmer et al., (2008) had found the overriding concern of medical residents was ease of use.

Studies of physicians’ use and non-use of EMR are remarkably similar in their findings. Physicians are guardedly attracted to the idea of EMR and by the possible benefits of EMR for their practices and for their patients, but are not yet convinced because they have not seen clear, rigorous proof in the literature. Many authors start their work with a lamentation of low EMR adoption rates among physicians (See for example, Randeree, 2007, Kaushal et al., 2009, Holden, 2010). Indeed, the literature is rife with cautionary tales of implementation failures (Randeree, 2007), the high costs of migrating from paper to electronic records (Davis, 2008), information access and ownership (Flegel, 2008), patient
privacy and information security issues (Thomas, 2008), compromised short-term office performance (Ludwick and Doucette, 2009), and negative impacts on physician-patient relationships (Shachak and Reis, 2009). Ilie, et al., (2007) found that physicians’ EMR behavior is primarily determined by their attitude and perceptions about EMR use: the complexities of using EMR and their perceptions that their EMR system was not compatible with their workflow were barriers to EMR use.

Surprisingly, those electronic functions that would seem obvious in their improvement over paper records, such as point-of-care computer reminders; have much smaller improvements in care than expected (Shojania et al., 2010). Weingart et al., (2009) report that the providers in their study were ambivalent about whether e-prescribing improved their own or overall office efficiency. Even when an EHR has been customized to physicians’ communication practices, there was no notable difference in the proportion of physicians using the system (Jerome et al., 2008).

O’Malley et al., (2010) studied the EHR experiences of physician practices and report six major themes that emerged:

1) EHRs facilitate within-office care coordination chiefly by providing access to data during patient encounters and through electronic messaging.

2) EHRs are less able to support coordination between clinicians and settings, in part due to their design and lack of standardization.

3) Managing information overflow from EHRs is a challenge for clinicians

4) Clinicians believe current EHRs cannot adequately capture the medical decision making process

5) Realizing EHRs’ potential for facilitating coordination requires evolution of practice operational processes

6) Current reimbursement encourages EHR use for documentation of billable events and not for care coordination.

Lastly, a study of Australian healthcare managers (England and Stewart, 2007) found that these executives have a lack of confidence in the IT solutions available to them and that IT vendors act inappropriately. They do not believe there is a compelling business case for IT investment and they do not believe that effective clinical IT exists. Given the negative tone and significant concerns in the literature, one cannot be surprised at the low EHR adoption rate among physicians.

**EMR: Organizational Level - Purchase, implementation, and use:**
In the same vein as the practitioners discussed above, much of the organizational level literature is cautiously optimistic about EMR while voicing deep concerns and reservations about its costs and effectiveness. We will first discuss literature focusing on hospitals and then discuss physician practice literature.

MacKinnon and Wasserman (2009) investigated the critical success factors for EMR systems implementation and found that an understanding of Enterprise Resource Planning (ERP) systems contributes to successful implementation: treating EMR systems as a type of ERP was a success factor for implementation.

Jha et al., (2009) state that despite the industry’s overall expectations that health information technology should lead to more efficient, safer, and higher quality care, “there are no reliable estimates of the prevalence of adoption of EHR in U.S. Hospitals” (p1628). This study found that the steep cost of purchasing and maintaining EHR are the primary barriers to its use in hospitals. Himmelstein, Wright and Woolhandler (2010) examined computerization’s cost and quality outcomes across 4000 U.S. hospitals, asking whether computerized hospitals had lower costs of care, lower costs of administration, or better quality. They found that hospitals that increase their computerization faster had more rapid administration cost increases and that computerization scores correlated weakly with better quality scores for acute myocardial infarctions but not for heart failure or pneumonia. Hospitals on the ‘Most Wired’ list performed no better than others on quality, costs, or administrative costs. They concluded that as currently implemented, hospital computing might modestly improve process measures of quality but does not reduce administrative or overall costs (p 40). Similarly, Kazley and Ozcan (2009) found little evidence that EMRs improve hospital efficiency and they conclude that “there does not appear to be a significant increase in efficiency over time associated with EMRs” (p209). In earlier work, these authors investigated the factors that influenced hospitals to adopt EMR. They found that hospital adoption of EMR is significantly associated with environmental uncertainty, type of system affiliation, size, and being urban. Factors not associated with EMR adoption include: competition, munificence, ownership, teaching status, public payer mix, and operating margin. Finally, barriers to EMR adoption found in this study were smaller size, being more rural, being not associated with a system, and low environmental uncertainty (Kazley and Ozcan, 2009).

Working to provide a conceptual benchmarking model for the use of health IT, Palacio, Harrison, and Garets (2010) reiterate the barriers its implementation: cost, lack of
financial incentives, and the need for interoperable systems. These findings mirror the study of Australian health managers discussed above.

Turning to the use of EMR in physician practices, Torres (2010) states that, for physician practices, the cost of implementation outweigh any financial incentives provided under the US Health Information Technology for Economic and Clinical Health Act (HITECH). Citing a data from Avalere Health, Torres writes that upgrading EHR can cost $124,000 per doctor in a small practice, which easily overshadows the $44,000 government incentives including the $5,100 per year penalty for non-adoption.

In addition to the cost of implementation, are the issues of effectiveness and quality. Linder et al.’s (2007) study of EHRs found that there was no significant difference in performance between visits with versus without EHR. They conclude that as implemented, EHRs are not associated with higher quality ambulatory care. This echoes Metzger et. al.’s (2010) study of hospitals’ meaningful use of EMR, which found that a Computerized Physician Order Entry system (CPOE) simulation detected only 53% of fatal medication errors and only 10-82% of serious adverse drug events.

Reardon and Davidson (2007) found that stakeholders need to do a better job of communicating the plausibility of EMR and at presenting representations of the EMR before an independent physician practice will find the organizing vision as clear, consistent, rich, and as balanced as it needs to be to be approved for adoption.

The Medical Group Management Association’s 2007 study investigating the experiences of their members’ adoption of EHR reports that much hard work and planning is required to enhance the probability of a successful EHR implementation. In addition, practices should expect increased operating cost and decreased productivity during the first two years of implementation, yet after those first two years, the benefits of EHR should begin to exceed the costs of implementation.

In one of the few studies that explores EMR from the patient’s perspective, Sibona et al., (2010) report that physicians earn higher satisfaction ratings from their patients when they retrieve and enter patient information using a computer. However, overall, patients do not believe that physicians who use EMR produce better health outcomes than those who don’t.

**EMR: Systems/National Level – Meaningful use:**

It has been observed that there are a number of analogies and similarities between the airline and healthcare industries and the “birthing pains” of their computing. Sherlock and
Chismar (2006) optimistically predict that, just as the airlines’ computerized reservations systems evolved into vertically integrated, interoperable systems, so will healthcare’s EMRs.

EMR adoption and implementation is a concern worldwide, Sood, et al., (2008) citing challenges faced in developing countries that hinder the development and progression of EMR, suggest that developing countries need to build on current structures of healthcare databases and technologies which have already been shown to work adding only relevant and disease specific modules unique to each country’s needs as they evolve.

Despite the somewhat pessimistic tone and the challenges faced in many nations, much of the national-systems level literature continues to state unequivocally that EHRs will make healthcare more evidence based, efficient, and less error prone (Wilson, 2009). Callan (2008) touts EMR as driving higher quality care through the availability of access to outcomes data. Highly positive articles such as Callan’s, that applaud the benefits and soaring outcomes of EMR, are primarily editorial in nature and talk about “trends that support the use of health information technology” (p 69). It seems intuitive and undeniably clear that the use of health IT in general, and EMRs in particular, should result in higher quality and more efficient care, yet there are few refereed publications presenting a rigorous analysis of data that clearly documents the anticipated and promised benefits of EMR.

Many nations continue to work toward, and provide incentives for, the adoption and use of EMR. As a case in point, in an effort to increase the adoption and use of EHR, The United States’ Centers for Medicare and Medicaid Services (CMS) have proposed a definition of the meaningful use of EMR technology. This rule is to be used to implement HITECH provisions of the American Recovery and Reinvestment Act (ARRA) that will provide incentive payments for the meaningful use of certified EHR technology. Eligible physicians can be reimbursed for up to $44,000 for adopting a qualified EHR. Hospitals are also eligible to receive incentive payments under the HITECH initiatives.

3.2 Clinical Systems & Administrative Applications of Health Information Technology.

One of the features of an EHR is to “exchange electronic information with, and integrate such information from, other sources.” (Wilson, 2009). Information from the Laboratory, Radiology, and Pharmacy, as generated through a Physician Order Entry component, have been imported into clinical EHRs (Trimmer et al., 2009). Additional systems that may be integrated into an EHR consist of Observation, Diagnosis, Therapy, Blood Bank, Nutrition, and Referrals (Cheng et al., 2004). The literature on other clinical
systems is dominated by discussions of Radiology Information Systems/Picture Archiving Communication Systems (RIS/PACS), Laboratory Information Systems (LIS), and Pharmacy Information Systems (PIS). Each of these is discussed with the individual, organizational, and system lens.

**Radiology Information Systems/Picture Archiving Systems (all levels):**

Regarding individual level, many studies (Lepanto et al., 2006, Ayal and Seidmann, 2009) have workflow as a focal point of their research, with reductions in transcription turnaround time and report turnaround time being observed as a positive impact of implementing PACS.

In a review of PACS success, Pare et al., (2005) focus on use, user satisfaction, and individual impact, in addition to organizational impact, as dimensions that influence PACS success. They found that high user satisfaction is present with the use of PACS. Increase in radiologist productivity is also an individual outcome of PACS. Using the Pare et al., (2005), framework as a research model, Tually, Stavrainou, and Walker (2005), report broad user satisfaction with a web-based radiology system.

Another research project evaluating PACS that addressed both individual and organizational levels was performed by Ayal and Seidmann (2009). They found significant improvement after the PACS was implemented with process related factors. Furthermore, increased satisfaction was observed with final reports, imaging availability, scheduling, and information.

Final radiology report utilization by clinicians was evaluated by Hurlen et al., (2010) in a study integrating the RIS with the Patient Record. The researchers found evidence that clinicians in general, and orthopedic surgeons in particular, did not read all final reports. Because no significant difference was found in the percentage of reports read after a year of implementation, the researchers concluded that, because there was no change in the routine of the radiologists in generating preliminary and final reports, revising the workflow is an option to gain improvements in quality and time of reports.

An underlying issue in the implementation of RIS/PACS in the organization involves costs. “Film and film-related savings that are associated with PACS implementation come from the elimination of (1) the film library, (2) film processors, (3) darkroom and film library personnel, and (4) film costs for specialties (number of procedures, sheets, etc.),” (Ayal and Seidmann, 2009 p. 45) In pointing to an emerging need, Ayal and Seidmann (2009), call for enhancing the interface between Radiology and other departments. Despite costs, RIS/PACS
systems have an “increasing presence of medical imaging within clinical care” (Bui et al., 2007 p. 94).

The systems level perspective, discussed by Hurlen et al., (2010), reflects the integration of the RIS/PACS with the EPR as an illustration of the meaningful use of integrated EMRs. In this study, the system logged the accessing of preliminary and final reports by clinicians. In investigating the preliminary and final reports view by clinicians ordering the images, the researchers found that less than half of preliminary imaging reports and 88% of final reports were opened within four weeks after being available. The authors discuss workflow and overall control issues as being a potential cause for the clinicians not reading all available reports. They researchers comment that some clinicians may read the image and make their own interpretation, and did not find it necessary to read either the preliminary or final report. The researchers conclude with a recommendation to review collaboration routines between radiologists and clinicians to increase the percentage of reports read by clinicians.

Technology challenges still exist. Cheng, et. al., (2004) provide an in-depth discussion of HL7 (Health Level 7) protocol compliance challenges in the RIS/PACS environment. In the web-based study by Tually, et al., (2005), broadband constraints were seen as a primary RIS/PACS system level obstacle. In looking at technology advancements, strategies such as using Extensible Markup Language (XML) in the generation of reports by technicians and radiologists may address this challenge by making reports more Internet available (Hur, Lee, and Kim, 2006).

Laboratory Information Systems (all levels):

Clark, Carter, and Sullivan (2004) assessed the use of a system that provides desktop access to laboratory results over a 12 month period by United Kingdom general practitioners who had at least six months experience with the system. The researchers found that all practitioners with access to the system used it. They also found that initial access patterns, categorized as high, medium, or low, continued throughout the study period.

User satisfaction with both the LIS and its outcomes has also been assessed. In 2010, Salinas et al., (2010) found patient satisfaction with the LIS increased as the LIS was used where the processes were continuously improved. This increase in satisfaction was attributed to an improved overall lab results process. In a study of an internet based LIS in Peru, García et al., (2009) found an ongoing benefit from gaining user feedback on the use of the system by clinicians and patients. As users were provided with improved information, their use of the system increased.
At the organizational level, Park et al., (2005) in a study of LIS and general revenue, point out that in 1999, in the United States, between 80 and 100% of hospitals were using a LIS, whereas Korean hospitals were at under 50%. They found a positive relationship between implementing the LIS and revenues.

Some studies provide organizational guidelines. Salinas, et al., (2010) provides a set of indicators used to measure overall LIS performance in a certified laboratory that could be transferred to other organizations for purposes of process improvement. They broke the indicators into four dimensions, pre-pre analytical, pre-analytical, analytical, and post analytical dimensions. The identification of the metrics along these dimensions allowed the organization to focus on areas to improve their processes as measured by increased user satisfaction with the entire lab result process. In another study, 25 items, ranging from the ability to support automation to Security and Privacy for HIPAA concerns were identified to assist an organization in selecting an LIS (Noble, 2002).

Interoperability between the LIS and other systems within the enterprise was called for by Berge et al, in 2007 (2007). Currently, middleware offers solutions for enabling interoperability between the LIS and the EHR.

The work of Garcia, et al., (2009) and Clark et al., (2004) highlight a broader societal issue for the availability of LIS reports. Both required a level of access that can reside on the Internet. As molecular and genetic testing become more prevalent in laboratory tests, and clinicians become increasingly shorter in supply, the workflow structure and capabilities of the LIS will likely evolve, including the use of more technology-based tools (Rogoski, 2010).

Pharmacy Information Systems (all levels):

By initially framing Pharmach Information Systems (PIS) as a strategic information system, by placing connectivity in the hands of individual pharmacists, McKesson introduced changes to the pharmacy workflow (pharmacists were enabled to enter orders for both prescription and non-prescription medications, as well as other pharmacy supplies) (Clemons and Row, 1988). Studies show that successful implementation of PIS for the organization reduces medication errors (Nicol, 2007). In addition, as with RIS/PACS, reductions in the number of work steps can be achieved by use of a PIS, and medication turnaround times decrease (Nicol, 2007). A 2008 study of a Wisconsin based health network underscores the importance of understanding and tailoring workload to the PIS (Meidl et al., 2008).

At the systems level, Chaffee and Bonnasso, (2004), discuss four associations between and LIS and EHR: 1) EHR has a LIS, 2) bi-lateral interfacing with a CPOE that is present in an EHR 3) uni-lateral interfacing with the CPOE that is present in the EHR 4) no
integration. In a companion article, Chaffee and Bonnasso (2004) discuss the interfaces in the bi and uni lateral environments stating that EHRs must engage a strategy to pass data between the systems. The authors provide a discussion and examples of using the HL7 protocol, including the messaging components associated with the LIS.

### 3.3 Telemedicine

**Telemedicine Individual Level:**

As with EMR technologies, TAM and UTAUT have been used as theoretical basis to study individual level telemedicine issues. Multiple studies extend these models in light of the health care context and the use of telemedicine. For example, Nwabueze, et al., (2009) extend the UTAUT model by incorporating cultural constructs into the technology acceptance model. What emerges from the results of this study is that various cultural characteristics are important in the transfer of a new technology to medically underserved communities and cultural variance may explain why telemedicine programs in some communities may fail.

A broad number of applications under the umbrella of telemedicine have been increasingly investigated over the years with various constructs of interest. For example, Wu et al., (2005) studied mobile applications asking what determines health professionals’ acceptance of mobile healthcare technology; they conclude that compatibility and self efficacy have significant influence on intentional behavior. Management support, as they had hypothesized, did not influence behavior in this study. There are some variables, such as the ease of use and perceived usefulness (from TAM), that have been addressed in the study of many telemedicine applications. However, due to variants in constructs introduced in extending core TAM constructs, it is not yet known if the significant antecedent variables to acceptance of one type of telemedicine application carry over to acceptance of other telemedicine applications.

At the core, most telemedicine is a technology-mediated communication process among people. Research has recognized the unique challenges of the communication process in the health care context. Brown et al., (2003) introduce the circumplex model as a framework for understanding the development of trust in telemedicine as a function of trait, trust, and collaboration.

Patients are either key direct or indirect users in most telemedicine applications. Thus, the characteristics of health care consumers/patients need to be considered. Among the recognized barriers for home health solutions are low computer literacy and low health
literacy among the targeted patient populations that could potentially benefit the most. For example, of the 29% of the U.S. population over age 65 who are living with a chronic condition, 25% have less than a high school education (Slocum, 2008). Regarding health care consumer’s vision of the future, the citizens of seven countries in Europe indicated low expectations regarding the likelihood of having consultations with health professionals or being able to schedule appointments online in the recent past. Only experienced Internet users have high expectations in the future (Santana et al, 2010).

With telemedicine, and perhaps the other applications addressed in this study, benefit and ultimately adoption and diffusion are not just a matter of use, but “use quality”. Defining use quality, LeRouge and Hevner (2005) highlight that the way the technology is used or ‘use quality’, may affect effectiveness and ultimately diffusion for medical video conferencing. Thus, from an individual perspective, we not only have to consider “who,” but also “how” individuals (health care consumers and/or providers) use the technologies.

**Telemedicine Organizational Level:**

Insight into successful operating strategies and value for sustainable telemedicine programs within health organizations are not clearly evident in research or practice (Aoki et al., 2003). Reported pilot successes (e.g., reduced referrals, increased access to services) are no guarantee that pilot projects will transition to a successful long-term service solution (Fursse and Clarke, 2006). As stated in a recent article, we are dealing with a grave underestimation of telemedicine organizational problems (Aas, 2007).

However, there are multiple reported successes from an organizational perspective. For example, Paré, et al., (2008) concluded that the implementation of tele-home care software had positive effects on staff productivity and upon accessibility to care services. Specifically, the software allowed the allocation of an additional hour of patient care. Another study of tele-home care found that nurses were able to increase the number of home visits as well as devote more time to patient care rather than on paperwork. Dhillon and Forducey (2006) reviewed effectiveness evaluation techniques of telemedicine systems using medical video conferencing for direct patient care and reported successful utilization in regard to access, quality, and cost in a rural tele-health system.

While there are potential advantages and benefits from telemedicine, the evidence of its cost-effectiveness and sustainability is meager concluded Wright (1999). Telemedicine undoubtedly yields cost savings in certain circumstances, but few service providers have found a way to recover their costs (and make a profit) from those to whom they provide their service. One complexity is that many telemedicine pilots are grant funded and may take a
project, rather than sustainable program perspective. Another issue seems to be clear definition of value and fit with the context. The Health and the Information Highway Department, a Canadian government health agency, indicated in a 2004 report that the key dimensions of sustainability planning include: (1) Validating the mission and vision and determining future direction, and (2) Capturing and communicating the benefits. As indicated by these two dimensions, to achieve sustainability, much can be lost if an advocate of telemedicine cannot demonstrate to senior management how the telemedicine program contributes value to their organization’s mission.

Value and purpose considerations are not a singular task in the case of telemedicine. Telemedicine service delivery requires at least two different entities (provider and the receiver). As service providers explore telemedicine, the characteristics of both entities must be considered to define a telemedicine program that provides a viable value proposition for both for adoption and sustainability. Darkins and Cary (2000) provide a hypothetical case for tele-radiology that well illustrates the need for collaborative assessment of strengths and weaknesses in evaluating telemedicine’s fit within the overall organization. The organizational context involves two health organizations. Organization A is a small clinic that has an overall organizational strategy to increase its revenue through expansion of services. Internal weaknesses include limited radiology services. Organization B is a group of radiologists or a large hospital with complementary goals and a radiology capacity that can handle providing teleradiology support services to the small clinic. This scenario underscores that the telemedicine value proposition is a collective assessment that may merit a supply and demand perspective in view of internal and external factors.

Mun et al., (2005) stated that ultimately the successful business model will depend on the ability to produce the highest-quality product at the lowest cost. Thus, to assess value potential, the most appropriate evaluation should be aimed at investigating the benefits and costs of alternative modalities and various dynamic combinations and configurations of technology, human, resources, and health applications (Bashshur et al., 2005). A recent study (Tulu et al., 2007) suggests that when planning new telemedicine programs or evaluating old ones, organizations need to take into account different dimensional characteristics including: a) size of organization, b) specialty of telemedicine program (e.g. dermatology, cardiology), c) all urban – urban/rural network, d) number of telemedicine programs, e) for profit/not for profit organization, f) years in operation, g) grant funded program/ not grant funded, f) all sites within one organization/ sites distributed across organizations. It is not a matter that any particular characteristic is a strength or weakness, but rather that these characteristics
influence the propriety or fit of various telemedicine options. In summary, it would seem that the telemedicine goals and application should fit the intra/inter – organizational context.

**Telemedicine National/System Level:**

Government and private investments in telemedicine around the world have spurred growth and implementation of programs within clinics, hospitals, and other health entities. Report Buyer forecasts that the global market for telemedicine will increase to over $13.9 billion by 2012, showing a compound average annual growth rate of 19% (Bailey, 2008). Lievens and Jordanova (2004) notice that though the telemedicine market is obviously growing, it is still unstructured, fractured and disorganized.

National policy and perspective regarding government’s role provides first level influence to technology adoption and diffusion. For example, with regard to policy, some of the current barriers to telemedicine in the U.S. include state laws prohibiting the practice of medicine across state boundaries and lagging reimbursement policies by insurance payers.

With regard to government’s role, some believe that strategy for telemedicine adoption and diffusion must start at the national level (e.g., Al-Qirim, 2005). Such a position advocates a governmental facilitator role, which develops a framework of guidelines and regulations, encourages partnership between healthcare providers and commercial system suppliers, and helps participating organizations address the legal and ethical issues accompanying telemedicine with an overall goal of providing a collaborative environment for healthcare professionals and companies. Others look at the role of a national plan involved with “identifying opportunities with respect to specialty care, rural coverage and medical needs, and other administrative objectives” (Al-Qirim, 2005). Neither perspective seems to be realized in even the most developed countries.

Some studies have started to highlight that successful telemedicine programs are dependent on individual, organizational, and national factors for successful programs with a systems-oriented perspective. Whittaker et al., (2004) identified three success factors: 1) the administration took a long-term view of the value of the telemedicine service (organizational level factor); 2) telediabetes enabled structured use of staff time and facilities (service delivery followed national diabetes standards) and 3) a well-defined cycle of care within a long-term quality improvement program. Another study found that the success factors for the long-term sustainability of the telediabetes program studied were internal dimensions, which were sensitive to the external pressures and constraints posed by the socio-economic profile of the patients and the relevant geography.
4. Expert Panel Methods

Our second method of providing insight to our topic of e-health is a practitioner expert panel. Expert panels are used to systematically solicit, organize, and structure collective judgments and opinions on a particularly complex subject matter from an authoritative group (Anderson et al., 1994). We assembled an expert panel of health care system authorities in management and decision maker roles in hospitals in the Netherlands to provide both closed and open-ended commentary related to the future of e-health. The aim of using the expert panel for data collection was to gain data that would provide authoritative insight and grounded experience regarding e-health. Expert panels have long been used extensively in information systems research to identify key issues for management action (Schmidt, 1997). Empirical studies in the field of health care indicate that a “well-designed expert panel can closely reflect the views of practicing physicians” and incorporate a range of views (Ayanian et al., 1998 p. 1896).

In accordance with past studies using expert panels, we sought a heterogeneous group of experts and preserved anonymity among panel members to provide comprehensive perspective and reduce bias (thereby increasing validity) (Linstone and Turoff, 1979). In reviewing empirical studies in the IS, marketing, management, and health-care domains using expert panels we found a range in the number of panel members (from three up, with many under 10) and nature of tasks performed (e.g. brainstorming exercise, interview, survey). In synthesizing this literature, the following seem to be determinants of the appropriate number of panel members required to ensure reliable and validated data collection: a) The ability to objectively assess the participant’s level of expertise related to the subject of interest and b) an adequate representation of divergent opinions necessary for comprehensive representation and closure on the topic of interest. Based upon the aforementioned criteria, we decided that between 12 and 24 participants would balance the need for panel heterogeneity with the demands of comprehensive and involved participation procedures (i.e. completing open-ended and closed-ended questions).

We identified and enlisted 17 noted health care experts from the Netherlands based on their acknowledged organizational and health care expertise and e-health awareness as assessed through the authors understanding of the organizations and programs. Many panel members had experience and/or knowledge of multiple e-health programs and roles, enhancing the knowledge pool. For example, participating coordinators and administrators also had hands-on provider experience and many participated in telemedicine and EMR.
programs. We make no claim about the representativeness of our panel, as the selection of our panel members was not random, but designed to enhance collective knowledge.

A document that provided the questionnaire was given to each participant along with a description the basics of the study and the response process. The questions were reviewed and revised by four researchers. All responses were analyzed and discussed in a public session enabling discussion amongst the panel members. Panel members were contacted via email and phone for follow-up, clarifying questions, where needed.

5. Expert Panel Results

EMR results

When asked their individual beliefs about EMR, participants responded that they believed that EHR will be as easy to use as paper records, will be a faster way to access and to find patient’s health information, and will make it easier to document care plans. When asked if they thought EMR would always be awkward to use they voiced strong disagreement.

In addition to their personal expectations for EMR, the participants answered questions addressing EMR’s overarching impact on healthcare on the organization and inter-organization levels. Even though the literature provides few strong, empirical studies with clear findings regarding the outcomes of EMR, participants disagreed that there is no solid evidence that EMR will improve patient care and that caregivers will not use EMR until there is solid evidence of medical error reduction. On the other hand, they agreed that evidence that EMR will live up to expectations would make caregivers more willing to use it. On the inter-organization and systems level, while most believe that EMRs will be the answer to their nation’s concerns about quality, they believe that it will take a long time for EMRs to deliver on expected quality. They are split on whether it will take a long time for EMRs to deliver on expected efficiency. They neither agree nor disagree that EMRs will be the answer to their nation’s concerns about cost of care.

In response to “I just don’t believe that EMRs are going to provide all the improvements they promise” the participants are evenly split. Similarly, in response to “I have seen many improvements in patient care since the use of EMR,” nearly equal numbers agreed, disagreed, and neither agreed nor disagreed. Finally, these participants agree that the increased accuracy of electronic prescribing is obvious but neither agree nor disagree that the accuracy of computerized order entry is obvious.
This expert data from the Netherlands reflects the overall cautious optimism/pessimism that is found in the EMR literature. There is an optimistic opinion of EMR in the Netherlands: on the individual level, nearly all experts recognize the benefits of EMR, believe that EMR will make finding and accessing records easier and will also make care documentation easier. In addition, at the organizational level, our panel believes that more evidence of EMR meeting expectations would make caregivers more willing to adopt and use it. Finally, the experts do not agree whether the nation’s concerns about quality and efficiency will be solved by EMR. They believe it is going to take a long time before all EMR promises are delivered, if ever.

Other Clinical Systems Results

Results from the panel of experts offer some insight into hopes and concerns for the integration of other clinical systems and EMRs. Faster access, increased health information, and better documentation are potential outcomes resulting from the integration of other systems and the results from the panel. Existing and future evaluation of work flows should provide improved efficiencies, ultimately resulting in some reduction in cost of care. Incorporation components to make a more complete record and information quality from the other clinical systems will also contribute to increasing the accuracy of the EMR.

Integration tools such as middleware and XML provide necessary inputs to widely available portals such as Google Health, and can enable pervasive EMRs. Conforming to standards, such as HL7 as well as certified laboratory and other clinical systems further push the pervasive EMR toward a broadly available decision tool for clinicians.

Telemedicine results:

About half of our respondents working in practice neither currently have telemedicine programs nor are planning to initiate a program over the next three years. Limited growth may in part be due to constrained government spending for telemedicine in the Netherlands, and the relatively recent adoption of the Dutch National Technical Agreement (NTA) for Telemedicine in 2007 (Meijer, 2008). However, the programs that do exist in the Netherlands appear to have celebrated reach. As indicated in a recent popular press article for telemedicine leaders, telemedicine systems such as Netherlands-based Phillips Visicu e-ICU already extend to many small critical care hospitals linking city-based specialists to rural areas for multiple forms of care (Lawrence, 2010).

Our data appears to mirror the situation of a limited number, yet expansive programs. Technologies used by the seven respondents with current telemedicine programs include store and forward technologies, high-end interactive video, low-end phone interactive video,
and webcam. All seven of the respondents indicated they engaged in the clinical activities with current program goals of telemonitoring, teleconsultation, nursing home/assisted living telemedicine, and managing patient conditions (e.g., chronic conditions). Six engage in tele-home health clinical care, mobile emergency response, and physiological monitoring. And, five engage in tele-rehabilitation programs. Four programs appear to be particularly active with current program goals in addition to those previously mentioned including the non-clinical purposes of education (4), training (4), grand rounds (3), meetings (3), tumor boards (4), community education (4), patient education (4), research (4), clinical trials (4), as well as the clinical purposes of non-surgical treatment (4), surgical treatment (3), patient screening (4) and specialist referrals (3).

The seven respondents with current programs indicated organizational plans existed to expand telemedicine initiative. All except one indicated expansion was in the form of adding new nodes (sites) either within or outside of their formal organization. Regarding the nature of program expansion, the following were noted as future goals (over the next three years) by respondents that did not already have current programs covering these areas: mobile emergency response (1), patient screening (3), specialist referrals (3), clinical trials (2), research (3), patient education (3), community education (2), meetings (1), and provider education (1).

When asked to provide insight regarding the telehealth future in the Netherlands, responses included individual, organizational, system, and national. Individual concerns such as considerations of impact on end users were noted. On the topic of organizational concerns, comments included the need for business modeling, knowledge sharing, and the evolution of best practices. One participant advised that organizations should start with simple and “smart” programs first and the move into integration and cooperation. On the subject of national issues, the financial and legal system was noted as barriers. In contrast, the infrastructure in the Netherlands was noted as being “very good”, which provided “future, bright success”. One system issue mentioned was the need for partnership between industry and science. Expert panel members also responded to this question with some thoughts about program innovation including coaching at a distance, including patient portals to enhance self-management and prevention-focused initiatives. In addition, one respondent provided the philosophic perspective that he envisions the future of telemedicine will add value to human care, but it should not act as a substitution for care processes.

6. Discussion – Future Vision
In this section, we integrate data from the literature review and the expert panel acknowledging all levels and applications in our research model. Our goal is to provide clarity to future directions by highlighting overarching themes for research and practice to consider.

In regard to EMR, our experts from the Netherlands reflect a more positive view for practitioners and organizations than does the literature, and this is highly encouraging. We suggest further work on all three levels to confirm our expert panel findings. Work is still needed at the individual level to tease out the substantive and non-substantive reasons for adoption and non-adoption of EMR. At the organizational level, questions of efficacy, quality, and cost remain overarching and call for empirical study and analysis. Finally, at the systems level, rigorous studies inquiring into the true costs and benefits to patients, organizations, communities, and to society in general are needed.

As with EMR research, a significant body of current scholarly research is lacking for the discussion of other clinical systems such as RIS/PACS, LIS and PIS. On ES there is abundance of literature but not specific to healthcare. Using the three primary clinical systems discussed, overall observations can be made regarding the future of other clinical systems. First, workflow is consistently mentioned as a process that undergoes significant change due to the implementation of the other clinical systems. The implementation of RIS/PACS, LIS, and PIS all eventually reduce the number of steps in workflow, and enable more to be done by fewer clinical professionals, seemingly without compromising user satisfaction.

Second, integration between these clinical systems and the broader EMR must be facilitated. Work on clinical systems to date typically look at a ‘best of breed’ or existing software in radiology, the laboratory, or the pharmacy rather than clinical systems that are a component of the EMR. This isolated perspective fails to recognize the myriad of practice management and technology integration issues and opportunities. With evidence of integrating RIS/PACS with electronic records, and the potential to integrate the LIS with the PIS, considerable opportunities exist to add value to the EMR through either integration with middleware or web based components, or the evolution of enterprise wide systems that provide this integration with ‘shrink-wrapped’ solutions. However, the experts we consulted do not predict a quick or easy integration of clinical, administrative and EMR systems: as one panel member put it, “we still have a long and bloody way to go.”
The use of middleware, messaging, and OpenSource are tools that can be used to facilitate this integration, not only within organizations with disparate systems, but also within the entire health provider network. In a multi-vendor environment, HL7 becomes a critical element in addressing integration issues. The Internet and associated technologies may serve as a primary method for facilitating the integration of other clinical systems with the EHR. Bui et al., (2007) offer the following comment (P 107).

Integrated multimedia patient records. The allure of the electronic medical record (EMR) is perhaps best given by the longitudinal, virtual patient record, seamlessly accessing and integrating imaging and all other modes of communication (text, graphical, video, audio) all into a comprehensive display. The juxtaposition of openSourcePACS and DataServer is a step in this direction, though the complexity of re-organizing and filtering the wealth of clinical information into a single interface is an ongoing challenge and topic of research. Indeed, as new imaging modalities become commonly available, novel techniques to visualize this data must be contemplated.

To move further towards its potential, practice and research need to explore ways to leverage traditional telemedicine media and emerging devices such as mobile phones and hand-held instruments and engage potential telemedicine participants to improve health care quality, access, and cost in light of individual, organizational, and national contexts. The experts agree that teleconsultation and telemonitoring (especially observable in diabetes care) are currently being used, but many of our telehealth subjects are not on organizations’ agendas at this point in time. Specifically, it seems that the telemedicine market needs a meeting place where the status of telemedicine and telecare can be reviewed in light of individual, organizational, and external environments. This approach may resolve any perceived conflict between telemedicine possibilities and business/national objectives.

7. Conclusion

The contribution of this study is an assessment key health IT systems with a futuristic perspective that aggregates up-to-date research with insight from practice using an organized framework. Specifically, we provide an in-depth perspective into the adoption and diffusion of IT in health care based upon a review of the most currently available literature and upon expert panel assessments of adoption and diffusion issues, achievements to date, challenges facing key e-health technologies, and future possibilities. It is evident that each level and each technology has its own set of ongoing questions and concerns that direct future research. However, it is also evident that the issues and opportunities associated with the various
technologies and levels overlap. This overlap does increase the magnitude of some challenges, such as systems integration. However, collective assessment of the various technologies and levels can enhance peripheral vision and thus avoid unanticipated obstacles or provide opportunities for synergistic leveraging as research and practice shape the future.

We caution the reader to consider the limitations of this study. Our primary caution relates to generalizability. Although we have valid reasons for the scope of our literature review, we recognize that there exists additional research both within and, perhaps, outside of the information systems domain that might extend this work. Additionally, our expert panel included participants from only one country. Though each of the panel members is acquainted with similar technologies and contextual situations, and some have researched or worked in other systems, we do not assert generalization. We leave it to future researchers to expand the scope of literature canvassed and/or explore the perceptions of experts from other countries to discover similarities and differences from those of this study.

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