Back to the future of IT adoption and evaluation in healthcare

Ton A.M. Spil

University of Twente,
PO Box 217,
7500AE Enschede,
The Netherlands
Email: a.a.m.spil@utwente.nl

Cynthia LeRouge

Decision Sciences/IT Management Department,
John Cook School of Business,
Saint Louis University,
3674 Lindell Avenue, DS 459,
Saint Louis, MO 63108, USA
and
Health Care Management and Policy,
School of Public Health,
Saint Louis University,
3674 Lindell Avenue, DS 459,
Saint Louis, MO 63108, USA
Email: lerougec@slu.edu

Ken Trimmer

Department of CIS,
College of Business,
Idaho State University,
Campus Box 8020,
Pocatello, ID 83209, USA
Email: trimkenn@isu.edu

Carla Wiggins*

Health Care Administration and Informatics,
University of Wisconsin – Milwaukee,
2400 E Hartford Ave, Room 411,
Milwaukee, WI 53211, USA
Email: wiggins@uwm.edu
*Corresponding author

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 healthcare 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. These data are synthesised 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, organisation and 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 healthcare sector.

Keywords: e-health adoption; e-health evaluation; HIT; health information technology; EMR; electronic medical record; EHR; electronic health record; HIT adoption; HIT evaluation; clinical HIT; telemedicine.

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Biographical notes: Ton A.M. Spil is a Researcher on e-health with a Master degree in Computer Science and a PhD on Management Studies. He is guest editor for *JSIS* and has edited two books on e-health. He is Track Chair in major conferences on e-health (AMCIS, ECIS and HICSS). He published in major journals and conferences on information strategy, business modelling and e-health innovation.

Cynthia LeRouge, PhD, MS, CPA, is an Associate Professor in the College of Business at Saint Louis University. She holds a joint appointment in the Department of Health Policy and Management at the School of Public Health, Saint Louis University. She completed her PhD at the University of South Florida. Her primary research interests relate to healthcare information systems. She has over 60 publications including academic journal articles, edited chapters in research-based books and peer-reviewed conference proceedings. She has co-chaired various healthcare conference mini-tracks and served as guest editor for multiple journal special issues on healthcare-related topics.

Ken Trimmer, PhD, MAcc, MBA, is an Associate Professor of Computer Information Systems and Accounting in the College of Business at Idaho State University. At ISU, he is the Director of the Health Care Information Systems Management Program, Director of Education for the Indigenous Nations Institute and Advisor to the Native American Business Administration Program. He received his PhD at the University of South Florida. His research interests focus on healthcare and pedagogical issues. In addition to his role as a mini-track co-chair, he is an author of over 30 referred journal publications, book chapters and conference proceedings.

Carla Wiggins, PhD, is an Associate Professor of Health Care Administration and Informatics at the University of Wisconsin at Milwaukee. She received her Doctorate in Health Services Research, Policy, and Administration from the University of Minnesota. She has a broad and ongoing interest in the use of information technology in the management of healthcare organisations. Her research explores the adoption, use and barriers to the use of Electronic Medical Records by providers and by health organisations. She is co-author of a healthcare management text book and has published a number of health management case studies and teaching notes.

1 Introduction

'If well funded and adopted widely, many different technologies – from electronic records to algorithms to remote monitoring devices – promise to streamline the healthcare 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 healthcare quality, access and cost improvements across the globe is contingent on adoption and diffusion. Healthcare is, by nature, a system that intertwines many individuals, organisations 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 organised 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 healthcare 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 (HIT)? 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 (a) a multidimensional review primarily consisting of papers accepted over the past seven years at arguably the most noted mini-track conference focused on IT Adoption, Implementation, Diffusion and Evaluation in Healthcare Information systems at HICSS and (b) 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 results of our literature review followed by the results of our expert panel. Our discussion section synthesises 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 synthesising 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 organisational 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

Level/Application	*EMR*	*Clinical and Administrative systems*	*Telemedicine*
Individual			
Organisational			
Systems/national context			

Source: Adapted from Spil et al. (2009)

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 HIT and its application. 'E-health' represents the broad array of electronic systems and applications that is 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 healthcare professionals, managers and consumers; to stimulate innovation in care delivery and health system management; and, to improve our healthcare 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/organisation and systems/national).

The terms, Electronic Medical Record (EMR), Electronic Health Record (EHR), Electronic Patient Record (EPR), and Personal Health Record (PHR) 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 within one health organisation that provides access to patient records and information, decision support, resources, and alerts. EHR and EPR are the active tools that electronically collect and maintain patient health and treatment related information gathered across at least two health organisations. Finally, PHR includes wellness and health information that may or may not be routinely collected or kept by health facilities, is controlled by the individual, and may or may not extend beyond one organisation. 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 EMRs. 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 prophesised for organisations? 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 healthcare information systems move towards 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 to 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'.[1] Telemedicine is one service that healthcare organisations provide with the help of collaboration technologies (such as video conferencing) to bridge locations within or among healthcare organisations. 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 programmes have shown to be clinically effective, it does not seem that the potential has 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 programmes from major IT general conferences and targeted meetings since 2000, the IT Adoption, Implementation, Use and Evaluation[2] 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 HICSS papers reviewed as part of the current study. Thus, the authors of this paper have not only individually or collectively read each HICSS paper, but have dialogued 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 that there are some limitations with the approach chosen for this study. However, this novel lens of using 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 recognised journals. Given our desire for currency in thought, we chose to closely canvass recent year's accepted submissions to the mini-track as the foundation for the literature review. 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 healthcare. 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

3.1.1 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 'behaviour 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 'behavioural 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 behaviour (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 HIT literature found the interruption of traditional practice patterns, lack of evidence regarding benefits of HIT, organisational 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, organisational issues of confidentiality, error reporting and physician time costs as primary barriers to physician adoption and use of EHR. Paré et al. (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 behaviour 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) reported 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 customised 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 standardisation.

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 Realising 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 or 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.

3.1.2 EMR: organisational level – purchase, implementation and use

In the same vein as the practitioners discussed above, much of the organisational 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) stated that despite the industry's overall expectations that HIT 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' (p.1628). This study found that the steep cost of purchasing and maintaining EHR is the primary barrier to its use in hospitals. Himmelstein et al. (2010) examined computerisation's cost and quality outcomes across 4000 US hospitals, asking whether computerised hospitals had lower costs of care, lower costs of administration or better quality. They found that hospitals that increase their computerisation faster had more rapid administration cost increases and that computerisation 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 (Himmelstein et al., 2010, 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' (p.209). 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 heath IT, Palacio et al. (2010) reiterate the barriers: cost lack of financial incentives and the need for interoperable systems. These findings mirror the study of Australian health managers discussed earlier.

Turning to the use of EMR in physician practices, Torres (2010) states that, for US physician practices, the cost of implementation outweighs any financial incentives provided under the US Health Information Technology for Economic and Clinical Heath 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 $44,000 government incentives including $5100 per year penalty for non-adoption.

In addition to the cost of implementation are the issues of effectiveness and quality. Linder et al. (2007) found that there was no significant difference in performance between visits with versus without EHR. They concluded 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 Computerised 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 organising vision as clear, consistent, rich, and as balanced as it needs 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 these 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 do not.

3.1.3 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' computerised 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 data bases 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) touted 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 towards, 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 US 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 and 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, has 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, organisational and system lens.

3.2.1 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) focused on use, user satisfaction and individual impact, in addition to organisational 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 et al. (2005) reported broad user satisfaction with a web-based radiology system.

Another research project evaluating PACS that addressed both individual and organisational 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 utilisation 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 orthopaedic 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 organisation involves costs. 'Film and film-related savings that are associated with PACS implementation come from the elimination of (a) the film library, (b) film processors, (c) darkroom and film library personnel, and (d) 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. The 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 et al., 2006).

3.2.2 Laboratory information systems (all levels)

Clark et al. (2004) assessed the use of a system that provides desktop access to laboratory results over a 12-month period by UK 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, categorised as high, medium or low, continued throughout the study period.

User satisfaction with both the LIS and its outcomes has also been assessed. 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 laboratory results process. In a study of an internet-based LIS in Peru, Garcia 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 organisational level, Park et al. (2005) in a study of LIS and general revenue pointed out that in 1999, in the USA, 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 organisational guidelines. Salinas et al. (2010) provide a set of indicators used to measure overall LIS performance in a certified laboratory that could be transferred to other organisations 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 organisation to focus on areas to improve their processes as measured by increased user satisfaction with the entire laboratory results 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 organisation in selecting a LIS (Noble, 2002).

Interoperability between the LIS and other systems within the enterprise was called for by Berg et al. (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) highlights 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 becomes 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).

3.2.3 Pharmacy information systems (all levels)

By initially framing PIS as a strategic information system, and 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 organisation reduces medication errors (Nicol, 2007). In addition, as with RIS/PACS, reductions in the number of work steps can be achieved by the 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 Bonasso (2004) discuss four types of associations between 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 Bonasso (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

3.3.1 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 healthcare 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 this 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 programmes 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 concluded that compatibility and self-efficacy have significant influence on intentional behaviour. Management support, as they had hypothesised, did not influence behaviour 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 of acceptance of one type of telemedicine application carry over to acceptance of other telemedicine applications.

At the core, most telemedicine applications are a technology-mediated communication process among people. Research has recognised the unique challenges of the communication process in the healthcare context. Brown et al. (2003) introduced 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 healthcare consumers/patients need to be considered. Among the recognised 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 US population over age 65 years who are living with a chronic condition, 25% have less than a high school education (Slocum, 2008). Regarding healthcare consumers' 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) highlighted that the way the technology is used or 'use quality' may affect effectiveness and ultimately diffusion for medical video conferencing. Thus, from an individual's perspective, we not only have to consider 'who', but also 'how' individuals (healthcare consumers and/or providers) use the technologies.

3.3.2 Telemedicine organisational level

Insight into successful operating strategies and value for sustainable telemedicine programmes within health organisations 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 organisational problems (Aas, 2007).

However, there are multiple reported successes from an organisational 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 to paperwork. Dhillon and Forducey (2006) reviewed effectiveness evaluation techniques of telemedicine systems using medical video conferencing for direct patient care and reported successful utilisation in regard to access, quality and cost in a rural telehealth system.

While there are potential advantages and benefits from telemedicine, the evidence of its cost-effectiveness and sustainability is meagre, 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 programme perspective. Another issue seems to be the lack of a 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 programme contributes value to their organisation'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 programme that provides a viable value proposition for both for adoption and sustainability. Darkins and Cary (2000) provide a hypothetical case for teleradiology that well illustrates the need for collaborative assessment of strengths and weaknesses in evaluating telemedicine's fit within the overall organisation. The organisational context involves two health organisations. Organisation A is a small clinic that has an overall organisational strategy to increase its revenue through expansion of services. Internal weaknesses include limited radiology services. Organisation 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) suggested that when planning new telemedicine programmes or evaluating old ones, organisations need to take into account different dimensional characteristics, including:

1 size of organisation

2 specialty of telemedicine programme (e.g. dermatology, cardiology)

3 all urban–urban/rural network

4 number of telemedicine programmes

5 for profit/not for profit organisation

6 years in operation

7 grant funded programme/not grant funded and

8 all sites within one organisation/sites distributed across organisations.

It is not 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 applications should fit the intra/inter-organisational context.

3.3.3 Telemedicine national/system level

Government and private investments in telemedicine around the world have spurred growth and implementation of programmes 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) noticed that though the telemedicine market is obviously growing, it is still unstructured, fractured and disorganised.

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 USA 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 organisations 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 realised in even the most developed countries.

Some studies have started to highlight that successful telemedicine programmes are dependent on individual, organisational and national factors for successful programmes with a system-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 (organisational 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 programme.

Another study found that the success factors for the long-term sustainability of the telediabetes programme 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 into our topic of e-health is a practitioner expert panel. Expert panels are used to systematically solicit, organise and structure collective judgements and opinions on a particularly complex subject matter from an authoritative group (Anderson et al., 1994). We assembled an expert panel of healthcare 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, p.763). Empirical studies in the field of healthcare 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 healthcare domains using expert panels, we found a range in the number of panel members (from three up, with many under ten) and nature of tasks performed (e.g. brainstorming, interview and survey). In synthesising this literature, the following seem to be determinants of the appropriate number of panel members required to ensure reliable and validated data collection:

1 the ability to objectively assess the participant's level of expertise related to the subject of interest and

2 an adequate representation of divergent opinions necessary for comprehensive representation and closure on the topic of interest.

Based on 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 healthcare experts from the Netherlands based on their acknowledged organisational and healthcare expertise and e-health awareness as assessed through the authors understanding of the organisations and programmes. Many panel members had experience and/or knowledge of multiple e-health programmes and roles, enhancing the knowledge pool. For example, participating coordinators and administrators had also hands-on provider experience and many participated in telemedicine and EMR programmes. 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 of the basics of the study and the response process. The questions were reviewed and revised by four researchers. All responses were analysed and discussed in a public session enabling discussion among the panel members. Panel members were contacted via email and phone for follow-up, clarifying questions, where needed.

5 Expert panel results

5.1 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 organisation and inter-organisation 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-organisation and systems level, while many 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 computerised order entry is obvious.

These expert data from the Netherlands reflect 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 recognise 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 organisational 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 that it is going to take a long time before all EMR promises are delivered, if ever.

5.2 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 increase 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 pushes the pervasive EMR towards a broadly available decision tool for clinicians.

5.3 Telemedicine results

About half of our respondents working in practice neither currently have telemedicine programmes nor are planning to initiate a programme 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 programmes 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 appear to mirror the situation of a limited number, yet expansive programmes. Technologies used by the seven respondents with current telemedicine programmes 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 programme 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 programmes. Four programmes appear to be particularly active with current programme goals in addition to those previously mentioned including the non-clinical purposes of education (4), training (4), grand rounds (3), meetings (3), tumour 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 programmes indicated organisational 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 organisation. Regarding the nature of programme expansion, the following were noted as future goals (over the next three years) by respondents that did not already have current programmes 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, organisational, system and national. Individual concerns such as considerations of impact on end users were noted. On the topic of organisational concerns, comments included the need for business modelling, knowledge sharing and the evolution of best practices. One participant advised that organisations should start

with simple and 'smart' programmes first and the move into integration and cooperation. On the subject of national issues, the financial and legal system were 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 thoughts about programme 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/she 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 organisations 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 organisational 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, organisations, 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. 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 reduces the number of steps in workflow, and enables 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 looks at a 'best of breed' or existing software in radiology, the laboratory or the pharmacy rather than clinical systems that are components of the EMR. This isolated perspective fails to recognise 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'.

Middleware, messaging and OpenSource are tools that can be used to facilitate this integration, not only within organisations 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 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 and audio) all into a comprehensive display. The juxtaposition of OpenSourcePACS and DataServer is a step in this direction, though the complexity of re-organising 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 visualise 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 healthcare quality, access and cost in light of individual, organisational 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 organisations' 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, organisational 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 organised framework. Specifically, we provide an in-depth perspective into the adoption and diffusion of IT in healthcare 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 are overlapped. 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 generalisability. Although we have valid reasons for the scope of our literature review, we recognise 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 generalisation. 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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Notes

1 Webster's New World Medical Dictionary.

2 This track has undergone some minor name changes over the years.