

Advances in Health Care Management
Volume 12

Health Information Technology in the International Context

Nir Menachemi
Sanjay Singh
Editors



HEALTH INFORMATION
TECHNOLOGY IN THE
INTERNATIONAL CONTEXT

ADVANCES IN HEALTH CARE MANAGEMENT

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ADVANCES IN HEALTH CARE MANAGEMENT VOLUME 12

HEALTH INFORMATION TECHNOLOGY IN THE INTERNATIONAL CONTEXT

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PREFACE

Nations around the globe have established policies designed to improve the computerization of their health care systems. It is believed that the adoption of health information technology (HIT) including clinical information systems, decision support systems, and networks or systems that facilitate the exchange of clinical and other health data will yield various desirable outcomes. These outcomes may include improvements in the quality of care, a reduction in medical errors, boosts in efficiencies, and improved provider and patient satisfaction. This current volume of *Advances in Health Care Management* presents a global perspective of the state of HIT in health care organizations and systems. The purpose of this volume is to facilitate the exchange of management theory, best practices, implementation challenges, and the impact of adoption as it pertains to HIT adoption in one or more international settings. This volume is organized into three sections which focus first on the broad perspective of HIT at a systems level; the second section includes chapters that examine HIT policies and issues within a single nation; and a third section is dedicated to chapters addressing specific types of HIT as they pertain to the international context.

SECTION 1: HIT WITHIN HEALTH SYSTEMS

Section 1 begins with an chapter focused on the state of health information exchange within and among nations. Vest writes of the relation of exchange efforts to national health care systems, the common challenges, and the implications of cross-border information sharing. Also written from a broader view is the chapter by Hotchkiss and colleagues that reviews the use of routine health information systems (RHIS) and makes suggestions for how to enhance their role in improving health system functioning. Their work outlines the “numerous knowledge gaps on the ability of RHIS to improve health systems functioning and performance” and puts forward a

call to assess the effectiveness of RHIS projects in order to build the evidence-base in this realm.

SECTION 2: HIT POLICY WITHIN INDIVIDUAL COUNTRIES

The four chapters included in this section examine HIT policy within individual countries. The commentary by Savage and van der Reis highlights trends in HIT and provides expert opinions regarding quality improvement and cost containment. In the second chapter, Chi and his coauthors use the case of Taiwan's National Health Care System to share their criteria for how to assess a national health care system. Such examples may be of interest to researchers and policy makers who need to build measurable criteria to represent specific objectives for a national HIT system. Additionally, Huerta and Ford provide a thoughtful reflection on the context of the United States' HIT policies, including discussions of the environment, social, regulatory, and financial dynamics that make the US HIT experience unique. Given the push to achieve widespread HIT adoption in the United States, Mazurenko and colleagues provide an examination of the use of HIT among international medical graduates working in the United States. They report that international medical graduates are less likely to have a comprehensive electronic health record in their practices, findings which highlight possible barriers to HIT adoption and which provide valuable information during a crucial HIT implementation period in that country.

SECTION 3: SPECIFIC TYPES OF HIT AND THEIR RELEVANCE TO INTERNATIONAL SETTINGS

Three chapters in this volume of *Advances in Health Care Management* specifically examine one type of HIT within the international context. Kazley and colleagues write of the uses, barriers, and future of telemedicine. Findings indicate that challenges surrounding reimbursement, liability, lack of standardization, technology, and provider licensing remain issues faced across borders. The second chapter in this section highlights the potential for using mobile IT to improve the quality of care provided in the home health care setting. This work by Breitschwerdt and colleagues highlights yet

another valuable use for HIT. In an attempt to implement and evaluate the use of an eHealth Program across 14 international sites, Kanter and colleagues chose an open source solution. Their chapter shares the lessons learned about open sources technologies as a bridge for disciplines and across countries. Further, their work provides justification for how open source solutions can contribute to efficiently attaining health objectives as outlines in the Millennium Development Goals.

We hope that this volume will provide researchers more insight into the state of HIT within various national and international settings. The contributions to this volume highlight many areas of future work and necessary HIT improvements to be able to get closer to the maximum benefit of these technologies to health care systems and services. After reviewing the excellent chapters included in this volume, we are reminded that numerous unanswered questions remain and we have just begun to scratch the surface of what there is to know about HIT.

Nir Menachemi
Sanjay Singh
Valerie Yeager

SECTION 1
HIT WITHIN HEALTH SYSTEMS

HEALTH INFORMATION EXCHANGE: NATIONAL AND INTERNATIONAL APPROACHES

Joshua R. Vest

ABSTRACT

Purpose – Health information exchange (HIE), the process of electronically moving patient-level information between different organizations, is viewed as a solution to the fragmentation of data in health care. This review provides a description of the current state of HIE in seven nations, as well as three international HIE efforts, with a particular focus on the relation of exchange efforts to national health care systems, common challenges, and the implications of cross-border information sharing.

Design/methodology/approach – National and international efforts highlighted in English language informatics journals, professional associations, and government reports are described.

Findings – Fully functioning HIE is not yet a common phenomenon worldwide. However, multiple nations see the potential benefits of HIE and that has led to national and international efforts of varying scope, scale, and purview. National efforts continue to work to overcome the challenges of interoperability, record linking, insufficient infrastructures,

governance, and interorganizational relationships, but have created architectural strategies, oversight agencies, and incentives to foster exchange. The three international HIE efforts reviewed represent very different approaches to the same problem of ensuring the availability of health information across borders.

Originality/value – The potential of HIE to address many cost and quality issues will ensure HIE remains on many national agendas. In many instances, health care executives and leaders have opportunities to work within national programs to help shape local exchange governance and decide technology partners. Furthermore, HIE raises policy questions concerning the role of centralized planning, national identifiers, standards, and types of information exchanged, each of which are vital issues to individual health organizations and worthy of their attention.

Keywords: Health information technology; medical informatics; international; health information exchange; health care systems; electronic health records

INTRODUCTION

The shift to computerized patient records during the 1990s and the early 2000s was accomplished primarily with information systems focused on internal organizational operations and without an eye toward sharing patient information between organizations. Therefore, electronic patient records were created and maintained in isolated, non-interoperable data silos – an approach that essentially replicated a limitation of their paper record predecessors (Brailer, 2005). A patient record that cannot be easily shared between providers inhibits coordination of care, limits the information available for decision making, and can make care less timely (Hripcsak et al., 2007). Health information exchange (HIE), the process of electronically moving identified patient-level information between different organizations (The National Alliance for Health Information Technology, 2008), is a solution to isolated and underutilized health information (President’s Council of Advisors on Science and Technology, 2010).

A small, but growing, body of literature indicates societal, organizational, and patient-level benefits from HIE. In terms of costs, the MidSouth eHealth Alliance in Memphis, TN, reported an association between the usage of HIE in emergency departments and a savings of nearly \$2 million

(Frisse et al., 2011). The majority of savings were due to a decrease in hospital admissions. These findings reinforced the results of an earlier randomized trial that demonstrated cost savings in the emergency department (Overhage et al., 2002). Cost savings may also be gained from workflow efficiencies, such as a reduction in time spent on the telephone looking for information (Kouroubali, Starren, & Clayton, 1998). An earlier effort at HIE also demonstrated improvements in provider communication and increased the availability of information in the area of diabetes care (Branger, van't Hooft, van der Wouden, Moorman, & van Bommel, 1999). Improved access to information from other institutions is widely reported in case studies and qualitative research (Mäenpää, Suominen, Asikainen, Maass, & Rostila, 2009). Finally, HIE is associated with overall organizational gains. For example, hospitals that have implemented HIE are associated with higher patient satisfaction scores (Vest & Miller, 2011). Likewise, in the ambulatory setting, physician access to electronic laboratory results was associated with higher quality scores (Kern et al., 2008).

This review provides an overview that describes the current state of HIE internationally. The following highlights how HIE efforts relate to the overall structure of their respective health care systems, common challenges, and the implications of cross-national information sharing for health care executives and policy leaders. In order to keep the scope of this review manageable, I have limited commentary to a selection of national and international efforts with descriptions in English language informatics journals, professional associations, and government reports.

DESCRIPTION OF HIE EFFORTS AND ACTIVITY

North America

HIE in the *United States* (US) is generally organized locally with significant state and federal technical assistance and funding. Locally created and governed collaborations facilitate HIE between different health organizations (Vest & Gamm, 2010). These collaboratives can be nonprofits, corporations, or government agencies and have been known by various acronyms, but Regional Health Information Organizations (RHIOs) and Health Information Organizations (HIOs) are the currently preferred terms. More than 230 HIOs exist (eHealth Initiative, 2010) and they each serve a geographically, socially, or medically defined population. Consistent

with a historic preference for local autonomy and information control (Brailer, 2004; Markle Foundation, 2004; National Committee on Vital Health & Health Statistics, 2006; Overhage, Evans, & Marchibroda, 2005), it is thought that each of these independent organizations can best meet the needs and preferences of their local communities and providers. This approach has resulted in various technical architectures, types of information exchanged, types of included partner organizations, and types of populations included (Adler-Milstein, Bates, & Jha, 2009, 2011). The most recent estimates indicate about 10% of US hospitals participate in an exchange (Adler-Milstein, DesRoches, & Jha, 2011; Vest, 2010).

The federal and state governments are working to decrease the likelihood that local HIOs do not become isolated data silos. The most important effort by the federal government is the Medicare and Medicaid Electronic Health Record (EHR) Incentive Programs, commonly called the Meaningful Use Program, introduced in the HITECH portion of the American Recovery & Reinvestment Act of 2009. Under this program, the government provides financial incentives for the adoption of electronic health records (EHRs) that conform to nationwide standards and where providers meet certain performance thresholds (Department of Health & Human Services, 2010). Incentives take the form of payments that can amount to \$44,000 over five years or \$63,750 over six years for providers, depending on the program specifics, and start with base payments of \$2,000,000 for hospitals (Centers for Medicare & Medicaid Services, 2011a). The set of 25 different performance measures for eligible professionals (physicians, nurse practitioners, dentists, and other depending on the program) (Centers for Medicare & Medicaid Services, 2011c) and the set of 24 performance measures for hospitals (Centers for Medicare & Medicaid Services, 2011b) are referred to the Meaningful Use criteria and give the program its common name. The prospect for widespread HIE is supported by these incentives, because the ability to exchange information with another organization is a Meaningful Use criterion. Subsequent stages of the Meaningful Use plan to increase the scope of information exchange (Department of Health & Human Services, 2010). Other national efforts at supporting HIE are centered in the Office of the National Coordinator for Health Information Technology (ONC) in the Department of Health & Human Services. In addition to providing funding to states and territories to build HIE capacity over a four-year period, the ONC has three initiatives designed at facilitating the sharing of information between HIOs, government agencies, and providers: the National Health Information Network (NHIN), the Direct Project, and CONNECT (Department of

Health & Human Services, 2011). NHIN and the Direct Project are described in detail elsewhere (Kuperman, 2011; *The Direct Project*, 2010); the primary lesson for health care managers is they are both essentially technology standards and exchange protocols for different types of users and use cases. CONNECT is an open source software application that supports HIE. At the state level, more than 75 pieces of legislation concerning HIE have been enacted since 2007 (CQ Roll Call, 2011; *National Conference of State Legislatures*, 2012). For example, New York state, one of the strongest supporters of HIE, has invested \$250 million to promote interoperable health information technology (IT) and funds HIE efforts across the state (Kern, Barron, Abramson, Patel, & Kaushal, 2009).

Canada's approach to HIE is a network of provincial and regional exchange efforts (called EHR Solutions) built on the same architecture and standards. Each jurisdiction maintains a fairly centralized technical architecture that relies on select data extracts from local health care and public health organizations information systems. These centrally stored data form the patient's EHR, viewable within the system, and in a fully mature implementation searchable across jurisdictions (Canada Health Infoway, 2006). While reminiscent of the US network of networks approach with RHIOs, Canada removes the substantial variation in technical architectures by using an approach that looks and functions in the same manner no matter the part of the country or size of the jurisdiction. Canada Health Infoway is the independent not-for-profit organization, whose members are federal, provincial, and territorial deputy ministers of health, that guides the nation's overall health IT effort by outlining the conceptual architecture of the desired, interoperable EHR (Canada Health Infoway, 2011; Giokas, 2005). As will be outlined below, other nations that have adopted a more centralized approach to health IT planning use equivalent-type entities with similar responsibilities.

Although Canada is employing a nationwide planning entity, several features reflect an attention to regional differences. First, Canada's strategy is technology and vendor neutral (Canada Health Infoway, 2006), which allows for some flexibility and individual choice. This approach of specifying capabilities not specific products is similar to technology certification in the United States. In addition, Infoway funds locally developed Health IT projects across the country based on local need. Finally, Infoway's governance structure ensures national coordination in a nation where health care responsibilities are distributed locally (Giokas, 2005). Canada provides universal coverage to all citizens for medically necessary care delivered by physicians or in hospitals through 13 comparable, but different, province

and territory-based insurance plans, but the provinces are responsible for funding care (Health Canada, 2010; Healthcare Information & Management Systems Society, 2009).

Canada still faces challenges in meeting its HIE goals. First, EHR adoption among primary care providers is low (Jha, Doolan, Grandt, Scott, & Bates, 2008) and few hospitals have moved to a complete EHR (Urowitz et al., 2008). Where electronic information has existed, working toward interoperability of legacy IT investments has proven to be difficult and costly (Healthcare Information & Management Systems Society, 2009; Sicotte & Pare, 2010). Finally, the move toward EHRs in Canada is not wholly a mandatory proposition. Regional Health Authorities have enough institutional authority to mandate participation by hospitals within their area, but that is not the case for the predominately private primary care providers (Healthcare Information & Management Systems Society, 2009).

Asia and Middle East

Japan's experiences with HIE were recently outlined by Abraham and colleagues (2011). Early grant mechanisms provided one-time funding for hospital-centric or local physician association-led regional HIE organizations. Most of the efforts could not transition from grant funding to a sustainable business model, faced technological limitations, and interoperability issues. In 2009 as part of an economic stimulus effort, Japan dedicated five years of funding to enhancing HIT with the idea that multiyear funding would provide sufficient time for organizations to develop sustainability. Japan espouses a local control model, but provides national recommendations, such as a preference for software as a service to minimize costs, use of international exchange standards, and privacy assurances. Importantly, Japan has not mandated HIE for health care organizations.

In many ways, Japan mirrors events in the United States. Both countries focus on local control as best meeting the needs of providers and patients. Their regional exchange efforts have experienced sustainability issues after grant funding expires, but successful examples exist. In addition, both countries have had to encourage exchange between very independent organizations and providers. While Japan has universal health coverage through a combination of employer-based and national insurance, hospitals tend to be private companies paid on fee-for-service model (Fukawa, 2002). Finally, both use national agencies for funding, policy development, and technological guidance, but the institutional influence being exercised

through extensive funding incentives and eventual penalties appears to be greater in the United States.

The state of HIE in *China* has been described as in “its early stage” (Liu et al., 2011) and “not widely adopted” (Liang, Xue, Byrd, & Rainer, 2004), but regional-based information exchange is a priority (China Hospital Information Management Association & Accenture, 2008). The effort described by Liu and colleagues (2011), a large hospital-centric system with a centralized data repository and centralized records, is consistent with the Ministry of Health’s vision. While concerns exist over general technological capacity, the primary identified barrier to HIE in China appears to be a lack of interoperability. International standards are not widely adopted, instead health care organizations utilize self-developed standards for everything from diagnoses, to demographics, to charges (China Hospital Information Management Association & Accenture, 2008; Liang et al., 2004; Liu et al., 2011). Lastly, as the country with the world’s largest population, HIE in China possess a problem of scale not seen elsewhere. In their description of the pilot phase of Peking University People’s Hospital RHIO, Liu and colleagues (2011) mention the data repository includes 10 million patients and more than 100 million clinical documents. In comparison, this pilot is of similar size to the largest and one of the oldest exchange in the United States, the 80 hospital Indiana Health Information Exchange (2011), and is twice as large as the nationwide exchange effort of Israel (Bolondheim, 2009).

China and *Japan* also participate in international HIE via the successfully piloted Global Dolphin (J.-s. Li, Zhou, Chu, Araki, & Yoshihara, 2011). The project is a collaboration of three universities with funding from both governments and covers frequent destinations for travelers between the two countries. Global Dolphin follows a network of networks model with the international level system providing record locator services, data transformation, and language translation. The Global Dolphin accesses records from each country’s participating regional exchanges. The regional exchanges, created earlier as part of the broader Dolphin Project, are centralized data repositories containing data from hospitals and clinics (J.-s. Li et al., 2011; Takada et al., 2005). A notable feature of the Global Dolphin is the use of a combination of (1) predefined standard terminology translation, (2) automated translation of free-text phrases, and (3) human translation of long free text. The latter is not performed in real time, but is completed prior to travel if the patient notifies the exchange.

More than 70% of the population of *Israel* is included in a single HIE (Bolondheim, 2009). The Health Information Network (HIN) provides

access to patient information “based on a comprehensive clinical database, virtually instantly created at the time and place of care and dissipated immediately at the end of the transaction” (Saiag, 2005). This federated model addressed data ownership concerns that arose from earlier efforts (Healthcare Information & Management Systems Society, 2009; Jones, Dobrev, Zegners, & Stroetmann, 2009) and supports patient privacy because the system has no means of locally storing information (Saiag, 2005). The HIN provides information from the hospitals and clinics of Clalit Health Services and two independent government hospitals (Mustacchi, 2009).

The extensive coverage of a single HIE effort in Israel cannot be disassociated from the structure of its health care system. First, the HIN can leverage a state mandated national identification number for record linkage (Healthcare Information & Management Systems Society, 2009). Second, it benefits from Israeli law which allows for “data exchange for the purpose of health care provision, regardless of the patient’s agreement” (Saiag, 2005). Third, reimbursement for primary care is tied to EHR usage, so Israel reportedly enjoys a high degree of EHR acceptance among providers (Jones et al., 2009; Saiag, 2005; Stanberry, 2011). Fourth, Israelis change insurance providers often and easily (Jones et al., 2009), a feature that can motivate providers to participate in HIE in order to manage the resultant disparate information and impeded continuity of care. Lastly, the scale of Israel’s HIE effort can be considered in many ways a reflection of Clalit’s market dominance. Israelis are insured and obtain health care services through one of four health maintenance organizations (HMOs), of which Clalit Health Services has the majority of the market share and controls a large number of the general hospitals (Healthcare Information & Management Systems Society, 2009; Saiag, 2005). The integration of information systems within such a large organization is an admirable achievement, but once completed, just the size of the integrated organization makes it an attractive exchange partner for other organizations.

Australia and New Zealand

Australia’s approach to HIE includes a history of local effort, a move toward centralized technology policy, and the adoption of a very patient-centric technology. During the last decade, Australia funded several state-level HIE pilot projects under the HealthConnect, a national program in

cooperation with states and territories supporting locally driven projects (Commonwealth of Australia, 2009), and other local efforts worked toward HIE (Deloitte, 2008; Jha et al., 2008). These efforts faced challenges of governance, difficulties in record linkage in the absence of national identifiers, a lack of standards, privacy protections, and workforce needs. These barriers are not surprising given the public and private combination that forms Australia's health care system. Under Medicare, the nation provides coverage for all inpatient visits at public hospitals, primary care visits, and a portion of inpatient visits in private hospitals (Australian Government & Department of Ageing, 2011a). Individuals desiring additional coverage or services from the nation's private hospitals have the option of purchasing private insurance (Australian Government & Department of Ageing, 2011b). As with other nations, this diverse mix of payers and providers yielded isolated data silos of non-interoperable proprietary systems (Deloitte, 2008; Morrison, Robertson, Cresswell, Crowe, & Sheikh, 2011).

The National E-Health Transition Authority (NEHTA) was created by the national, state, and territory governments to provide national e-health coordination and policy. NEHTA covers the issues of national data standards, exchange standards, security frameworks, and other e-health architecture related issues (Deloitte, 2008; Morrison et al., 2011; National E-Health Transition Authority, 2011). In addition, a purpose of NEHTA is "to lead the uptake of eHealth solutions of national significance" (National E-Health Transition Authority, 2011), two of which are worth noting. First, NEHTA leads the operationalization of Australia's national Healthcare Identifier Service. As noted, earlier experiences demonstrated complications in record linkage, and Australia has addressed that limitation by introducing a unique identifier associated with their national insurance program (Australian Government & Department of Ageing, 2011c). Second, NEHTA is responsible for managing the requirements and standards of the nationwide personally controlled electronic health record (PCEHR) system (Commonwealth of Australia, 2010, 2011). The PCEHR is a repository for health information aggregated from numerous sources where the patient decides who can access the information. Usage of the PCEHR is completely voluntary, but is promoted as a means to exchange information between providers (Commonwealth of Australia, 2010, 2011). Personal health records (PHRs), of which the PCEHR is a type, are used as the architectural strategy by more than one US RHIO; however, by routing information through the patient and not between providers, PHRs may be a less efficient form of exchange.

New Zealand's national strategic health IT plan calls for the use of four regional central data repositories linked into a national network (IT Health Board, 2010b). Patient data are contributed from local organization's information systems to populate the centralized data repository with a national set of core clinical information (IT Health Board, 2011). Providers will be able to access patient's virtual health records across the country by common patient identifiers. The country has utilized unique identifiers for health care purposes since 1993 (Protti, Bowden, & Johansen, 2008a). While the vision for a shared EHR includes all types of clinical information, New Zealand's model could be classified as fairly hospital centric. District Health Boards both operate the nation's public hospitals and are the entities aggregated into the four regional data repositories. New Zealand's approach is in many ways similar to Canada's: a common structure and standards for regional efforts that facilitate national exchange, but with regional flexibility through vendor choice, governance structures, and selection of additional information elements for inclusion in the repository (IT Health Board, 2010a, 2010b, 2010c, 2011). This represents a much closer alignment between health care system structure and HIE than would be possible in the United States, since coverage areas of RHIOs and other exchange efforts in the United States are based more on market areas than jurisdictional and payer boundaries.

New Zealand also has a relatively strong history of clinical messaging between providers (Protti et al., 2008a; Protti, Bowden, & Johansen, 2008b, 2008c). Public funding covers most health care spending and private physicians are paid on a fee-for-service basis with capitation (The Commonwealth Fund, 2010). Through a combination of one-time technology grants and required electronic claim submission, IT use in primary care is reportedly near-universal (Didham, Martin, Wood, & Harrison, 2004; Protti et al., 2008b). In this high usage context, HealthLink provides information exchange capability between providers in the form of clinical messages (HealthLink, 2011a) and a virtual health record based on a portal-type model for use during emergency encounters (HealthLink, 2011b). Notwithstanding the very wide use of HealthLink by New Zealand practices and hospitals (Protti et al., 2008b), a remarkable feature of HealthLink is that its exchange activities include organizations in Australia and a pilot effort in Canada (HealthLink, 2011a). While not the only international effort, HealthLink differs from other international exchanges on several fronts. First, the HealthLink business model is broader than HIE, as it also includes claim filing, referrals, and network security services. Also, HealthLink is a commercial operation supported by fees associated with usage volume,

whereas the European effort (as outlined below) is largely a governmental project. In terms of architecture, by facilitating exchange between organizations HealthLink is different than Global Dolphin, which was a linkage of two nation-based networks. Lastly, HealthLink connects organizations that have their own patient management systems or electronic records. A small exchange between a nonprofit primary care provider in southern Arizona (in the United States) and providers in Mexico cannot rely on that type of infrastructure. Instead the Arizona organization provides portal access to its EHR for the providers in Mexico to enter and view information for shared patients (Arizona Health-e Connection, 2012; Regional Center for Border Health, personal communication, January 19, 2012).

Europe

European nations were the focus of early evaluations of the benefit of electronically sharing patient-level information between providers, mostly using messaging type systems (e.g., Branger & Duisterhout, 1991; Branger et al., 1999; Bruun-Rasmussen, Bernstein, Vari, & Bercic, 1999; Hasman, Ament, Arnou, & Van Kesteren, 1992). The health IT capabilities and exchange strategies of European Union member nations have been recently well-documented in a series of country-level reports (eHealth Strategies, 2010) and other nations have been included in health IT cross-national comparisons (Healthcare Information & Management Systems Society, 2009; Jha et al., 2008; Morrison et al., 2011; Protti et al., 2008a, 2008b, 2008c; Protti, Johansen, & Perez-Torres, 2009). As would be expected, HIE in Europe ranges from the relatively nonexistent to the fairly comprehensive, occurs as regional networks or centralized EHRs, and is challenged by standards adoption and legacy system interoperability. Given the widespread recent national reports, this section is focused on describing the effort at international HIE in Europe.

Smart Open Services for European Patients, or *epSOS*, is a 23 nation, international HIE effort (epSOS, n.d.-b). The main foci of epSOS's first stage is the exchange of a shared patient summary record and e-prescriptions (Thorp, 2010) with the purpose of improving patient safety during international travel (epSOS, n.d.-a). The patient record summary includes demographic information, allergies, problem lists, medications, vaccinations, social observations, and recent surgical history (epSOS, 2010a); it is not a complete EHR (Stroetmann et al., 2011). epSOS does

not include direct connections between the health care organizations or providers, but instead is a federated network of national health information networks. For health care professionals participating in the pilot, epSOS functions like a record locator service that uses other countries' national identifiers and retrieves the summary document or e-prescription. Back end processes include: data extraction, language translation, and event logging (epSOS, 2010b, 2011). This network of networks operates within the constraints of independent national identifiers, different national health IT architectures, and the prohibition against altering any data within national systems. As part of this endeavor the project will also be reporting on the technical and legal challenges faced in international HIE (Lindén, 2009). The epSOS project receives funding from the European Union, agencies from participating countries, and other partners.

The fact that such a multinational HIE effort is a European effort should not be surprising. In contrast to other areas of the globe, European nations operate within the context of a larger political structure that is currently focused on the integration of electronic information on multiple fronts. Although the European Union structure and free movement of travelers provide a logical and supportive situation for an international HIE effort, the epSOS system faces technological hurdles not seen in other efforts. For example, epSOS is different than Global Dolphin, because the latter networked two architecturally similar regional systems, whereas the European systems are greater in number and architecturally different. However, both epSOS and Global Dolphin face translational issues, but again epSOS's hurdle appears higher given the number of nations involved. The diversity of technical architectures faced by the epSOS project is similar to the US challenge of information exchange among RHIOs. The problem for epSOS is complicated, however, by inconsistent usage of medical terminology and exchange standards among European nations (Stroetmann et al., 2011), whereas, the United States is dealing with different architectures, but at least within the context of recognized data and exchange standards.

DISCUSSION

Fully functioning and widely available HIE is not yet a common phenomenon worldwide. However, multiple nations see the potential cost and quality benefits of HIE and that has led to national and international efforts of varying scope, scale, and purview. These descriptions and cross-national comparisons provide insights for those in health care and for

those interested in broader health policy as well as indications for future research.

Implications for Health Care Managers

Health care managers cannot underestimate the political and institutional pressures for more widespread information sharing, nor can they afford to dismiss all the challenges associated with HIE as purely technical. In nearly all of the above outlined cases, and even for other nations not specifically detailed in our review, improvements in health care quality and reductions in costs are repeatedly identified as the motivation for HIE. Those alluring goals for the funding agencies, reform advocates, and shapers of health policy will ensure a sustained interest in HIE. In many nations this translated to effective mandates for HIE. In addition, while numerous technical challenges exist, HIE efforts still require managerial attention to organizational relationships, governance, and individual system adoption.

Due to a pervasive focus on regional approaches, health care organizations clearly have the opportunity to play an active role in shaping HIE in many nations. Although it is true that the width of that operating space varies from nation to nation, a narrow range of options does not mean organizational decisions are inconsequential. Even in instances with a single nationwide architectural plan, like Canada and New Zealand, the regional focus means differences in vendor choices, which is far from an unimportant decision. US organizations probably enjoy more latitude than most on the form and function of HIE due to the highly privatized system of care and multiple payer structure. In the US, organizations have to abide by exchange and data standards, but what organizations participate in each RHIO and what an effort's governance structure and business model looks like are at local discretion.

Even though not yet common, the potential utility of international HIE will continue to draw attention. Regular cross-border travel, disease surveillance, and medical tourism each suggest a role for international HIE (Fuller, Gadd, Fraser, & Ohno-Machado, 2010). Although, it could be expected that in many instances leaders of exchange efforts and managers of individual health care organizations may not find that a convincing business case for international HIE exists. For example, medical tourism is not for recurring primary care, but tends toward singular events like elective specialty surgeries (Horowitz, Rosensweig, & Jones, 2007). While the internationally generated information would be of undoubted interest to

patients' primary care providers, these events would not be repeatedly generating extensive amounts of information, nor would they be easily forgotten by patients. As to disease surveillance, those activities, at least in the US, are handled by the state and federal public health system and therefore would not be an organizational function of private hospitals and providers. A better case can be made for organizations servicing high traffic international borders. The underlying logic is pretty clear: a large number of individuals, a fixed number of countries with which to establish exchange relationships, and exchange benefits those crossing the border from either direction. This is essentially the logic of both ePSOS and the Global Dolphin. Some benefits might also exist for popular international tourist destinations given a sufficient volume of travelers. However, the utility of those efforts could vary significantly on a case-by-case basis, as the number of potential countries of origin for visitors could increase dramatically and little reciprocal benefit might be evident if international travel is not common for local residents.

The current article provides some guidance about what architectural forms and functions may be of best use to international HIE. First, during international travel the true utility of HIE is probably in emergency or urgent situations: that is the approach of Europe's ePSOS. Interestingly, the collaborative creators of the recently described Travelers' Electronic Health Record Template (TrEHRT), a PHR created specifically for international travel (Y.-C. Li et al., 2012), share that underlying approach. That perspective is consistent with the use cases described above and serves to bound the scope of what information is needed for international exchange. Second, a lesson of the Global Dolphin project is HIE efforts can exploit the purposeful nature of international travel. HIE efforts can use pretravel periods to ensure content availability for specific individuals and also to market their services to both international travelers and health care payers. Those two aspects, emergency needs and patient-level specific planning, suggest PHRs may be the most efficient means of international HIE in the majority of instances. PHRs do pose the challenges of relying on patients to manage their information, but can be overcome if the PHR is linked to a clinical data source (Archer, Fevrier-Thomas, Lokker, McKibbin, & Straus, 2011; Tang, Ash, Bates, Overhage, & Sands, 2006). RHIOs or organizations with their EHR could address that limitation. This may not be a substantial problem as typical emergency situations would need less information and the number of exchange partners would be very limited. Furthermore, the advantages of centralized repositories for data mining and quality reporting do not really apply in the international context; those are

more national concerns. PHRs could also support instances where international travel is to a specific provider, or where primary care is regularly sought internationally, but in those cases, a service like New Zealand's HealthLink could also be appropriate.

Implications for Health Care Policy

The challenges faced by HIE worldwide illustrate the need for national level health care information technology policies – particularly in the areas of standards adoption and financial support to ensure a sufficient IT infrastructure. The benefits of a national coordinated effort toward the adoption of international standards were evident from the interoperability challenges China faced in the absence of widespread standards adoption and the improvements in interoperability witnessed in the US and Australia after the move toward standards. In addition, multiple nations' HIE efforts were able to leverage the widespread acceptability of computers in health care. In the case of New Zealand this was due to previous government funding or in Israel where usage is tied to reimbursement.

The availability and use of national identifiers to match patient records is also a question of policy. HIE efforts in Australia, Canada, Israel, New Zealand, and dozens of European nations rely, or are planning to rely, on unique national identifiers. Notably, the US does not and instead attempts to rely on a poor set of multiple identifiers created for other purposes (Hillestad et al., 2008). Because of the record matching problem, exchange efforts in the United States invest heavily in creating master patient indexes. A national ID may not eliminate challenges in patient matching, but it would certainly put a damper on those costs and would help address potential identification and matching concerns in the Direct Project (Kuperman, 2011). Australia's recent introduction of a health care-specific, limited use national identifier could serve as a model for the US.

An additional concern may be the existence of narrowly defined exchange efforts: many efforts in the US are limited to specific populations or types of providers; examples of population-specific exchange projects existed in Canada; Israel's very wide exchange is not inclusive of smaller HMOs; and Australia may have a selection bias in who participates in the PCEHR. While the growing occurrence of HIE is a positive for patients, any divisions on the flow of information solely related to organizational or political factors, and not due to patient care patterns, is not in the patient's best interest. Very limited HIE has the potential to undermine many of the anticipated gains in

quality to be realized from exchange. External regulation or incentives may be necessary to ensure broader participation from all health care system participants.

Areas for Future Research

With the emphasis on anticipated cost and quality improvements, the present study highlights opportunities for several health services research type investigations. Clearly, interest will continue to grow in demonstrating HIE efforts are effective in improving patient outcomes and system performance. The numerous efforts described herein will provide ample opportunities to move from pilot studies and acceptability research into outcomes research. Nations that have a more uniform approach to HIE will be able to investigate these questions on a nationwide scale; whereas those with more diverse intra-national approaches will be able to move toward comparative evaluations of aspects such as technological architectures for HIE. In addition, as this review has indicated, HIE can be a source of interesting cross-national comparisons, particularly when considering how exchange relates to the overall structure of the health care system.

Limitations

The primary limitation of this review is that it is not exhaustive both in terms of nations included and technical details. More efforts exist than are described in this article, but the current review reflected a wide variety of activity within our language and space restrictions. In addition, our descriptions have not been overly technical. In our experience, approaches and plans for HIE can undergo frequent and rapid changes. Therefore, detailed technological specifications, available elsewhere, would not be useful nor of much interest to those interested in health organizations, management, and leadership. Lastly, the current analysis is not a review of the literature on the effectiveness of HIE.

CONCLUSIONS

The potential benefits of HIE make the widespread, easy sharing of patient-level information a desirable practice to support patient care. Advances in

technology and increases in EHR adoption worldwide have created an environment where HIE is becoming increasingly feasible. These common pressures have resulted in varied approaches to national and international HIE which still face significant challenges.

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HOW CAN ROUTINE HEALTH INFORMATION SYSTEMS IMPROVE HEALTH SYSTEMS FUNCTIONING IN LOW- AND MIDDLE-INCOME COUNTRIES? ASSESSING THE EVIDENCE BASE

David R. Hotchkiss, Mark L. Diana and
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ABSTRACT

Purpose – Health system performance depends on production and use of quality health data and information. Routine health information systems (RHIS) are defined as systems that provide information at regular intervals of a year or less to meet predictable information needs. These include paper-based or electronic health records and facility- and district-level management information systems. RHIS are receiving increasing attention as an essential component of efficient, country-owned, integrated national systems. To guide investment decisions on RHIS,

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evidence is needed on which types of RHIS interventions work and which do not.

Design/methodology/approach – This chapter is a systematic review of the literature on the evaluation of RHIS interventions in low- and middle-income countries, starting from the premise that investments in RHIS could be better understood and so produce greater benefits than they currently do.

Findings – We describe the conceptual literature on the determinants of RHIS performance and its role in improving health systems functioning, discuss the evidence base on the effectiveness of strategies to improve RHIS performance, provide an overview of RHIS evaluation challenges, and make suggestions to improve the evidence base.

Originality/value – The goal is to help ensure that (a) RHIS interventions are appropriately designed and implemented to improve health systems functioning and (b) resulting RHIS information is used more effectively.

Keywords: Routine health information systems; health informatics; information management; evaluation; service delivery; low- and middle-income countries

INTRODUCTION

Improving the use of health information is seen to be integral to scaling up the delivery of quality health care services (AbouZahr & Boerma, 2005; Evans & Stansfield, 2003; Sauerborn & Lippeveld, 2000). Improved information use requires improved quality of data and of information products, which in turn requires improved health information systems (HIS). In low- and middle-income countries, health information system strengthening has received unprecedented attention in recent years, as evidenced by the formation of the Health Metrics Network, the convening of the Global Health Information Forum in 2010 in Bangkok, and the unveiling of President Obama's Global Health Initiative, which calls for "strengthening existing public health surveillance and other data collection systems for monitoring diseases, conditions, health service provision, and health outcomes" as part of an integrated approach to strengthen health systems (U.S. Global Health Initiative, 2011).

Health data and information come from a variety of sources, including population-based sources, such as censuses, vital registration, and household surveys, and institution-based sources, such as facility surveys, facility records, and individual records (Health Metrics Network, 2008). As facility-based routine health information systems (RHIS)¹ only collect data on the services provided by those facilities and not services obtained from other sources (e.g., private commercial sector) and those who do not access health care at all, many consider nationally representative population-based household surveys to be the gold standard to track population health, risk factors, and health service coverage. However, nationally representative population-based household surveys are of little value for tracking service delivery, patient management, and underlying health system functions at the district and facility levels.

Health system managers at the district and facility levels require robust RHIS for evidence-based decision making (Lippeveld, Sauerborn, & Bodart, 2000). For example, to properly implement quality assessment and assurance strategies, RHIS data and information are needed to help ensure adherence to service delivery guidelines, to minimize medical errors, and to ensure that commodities are available. Broader health system reforms also require information from RHIS. Examples include pay-for-performance, where information is needed to verify whether prespecified targets have been achieved, and government-funded health insurance programs, where data and information are needed to deliver and pay for services that are part of a basic benefits package, and to monitor the quality of care. Fig. 1 depicts a framework of the linkages between investments in RHIS, the data they produce, use of health information, and ultimately health system performance.

Locally managed RHIS becomes potentially more valuable as countries decentralize health sector responsibilities. Over the past 20 years, as country

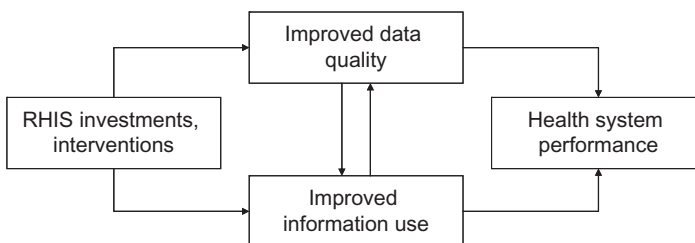


Fig. 1. Linkages between RHIS Investments and Health System Performance.

government health systems have become increasingly decentralized, officials at the district and facility levels have increased roles and responsibilities to make financial and managerial decisions. RHIS can play a key role in improving management and accountability capacity and mechanisms (Mills, Rasheed, & Tollman, 2006).

This chapter addresses the issue of improving and maintaining RHIS at the local level in low- and middle-income countries. A key premise of the chapter is that governments and nongovernmental organizations spend significant resources on RHIS and such investments could produce greater benefits at the district and facility levels than they currently do. To help guide decisions on how to invest in RHIS to improve health systems performance, evidence on the relative effectiveness of various RHIS strengthening strategies is needed. Evidence of effectiveness is particularly important as countries try to move away from parallel systems and toward using integrated national systems (Baughman & Nu, 2011).

The chapter is organized as follows. In the following section, we provide an overview of the methods used in the literature review. In the third section, we describe the conceptual literature on the determinants of RHIS performance and its role in improving health systems functioning and performance at the local level. In the fourth section, we discuss the evidence base on the effectiveness of strategies to improve RHIS performance. In the fifth section, we provide an overview of evaluation challenges and knowledge gaps. In the final section, we provide recommendations to improve the evidence base that can be used to help ensure that (a) RHIS interventions are appropriately designed and implemented to improve health systems functioning and (b) resulting RHIS information is used more effectively.

METHODS

Key definitions of RHIS, RHIS performance, health systems functioning, and health systems performance used in the study are presented below.

- *Routine health information system*: a system that provides information at regular intervals of a year or less through mechanisms designed to meet predictable information needs (Aqil, Lippeveld, & Hozumi, 2009). This includes paper-based or electronic health records and facility- and district-level management information systems.

- *Routine health information system performance*: data quality (relevance, completeness, timeliness, accuracy) and use of routine information for decision making.
- *Health systems functioning*: service delivery (i.e., service access, service efficiency, adherence to provider guidelines, reduced medical errors, improved patient tracking, improved tracking of equipment, logistics, and supplies), leadership and governance, human resources for health, financing, medicines, and supplies.
- *Health systems performance*: health outcomes (level and distribution), responsiveness (level and distribution), and financial protection.

For the purposes of this chapter, we view RHIS as consisting of a broad array of routine systems, including: surveillance systems for identifying the incidence of disease; individual medical records (paper-based or electronic) that can be used by doctors, nurses, and other types of health workers to improve the quality of care delivered to individuals; and facility-based systems (paper-based or electronic) that can be used by district- and facility-level officials to track the delivery of health care services and related support systems, including equipment and supplies, finance, payment, infrastructure, and human resources.

We conducted a literature search for RHIS evaluation frameworks research articles on the effectiveness of RHIS strengthening interventions. We searched PubMed and Web of Science for articles published from 1970 to 2011. The search was conducted from May to July 2011; and key words used were “routine health information systems”; “health management information systems”; “health information systems”; “electronic health records”; and “electronic medical records.” The search in PubMed yielded 2,681 articles, Web of Science generated 162 articles and 31 articles were identified from other sources, for a total of 2,874 articles. We also searched websites of organizations working on projects to strengthen RHIS, reference lists from identified articles, and references provided by colleagues.

To identify evaluation frameworks, we searched from within the 2,874 articles by using the keywords “model”; “conceptual”; and “framework.” We then reviewed the abstracts to identify articles that (a) present a conceptual framework that can be used to evaluate the effectiveness of facility-based RHIS interventions (either in developed or developing countries) and (b) discuss RHIS inputs, processes, outputs, or outcomes, which could include RHIS data quality and use as well as various aspects of health systems functioning and performance.

To identify articles that evaluate the effectiveness of RHIS interventions, two graduate researchers independently worked under the supervision of the authors to select from within the 2,874 articles that: (a) present a summative evaluation that assessed the impact of a technical, organizational, or behavioral intervention introduced for the purpose of improving one or more aspects of RHIS performance or health systems functioning, or both; (b) come from low-income and lower middle-income countries (based on the World Bank's classification of country economies into low income, lower middle income, upper middle income, and high-income categories); (c) include a clear presentation of the research methods used, which could include quantitative approaches with or without a control group or qualitative approaches that involve focus group discussions and in-depth interviews. The two reviewers independently eliminated articles that did not take place in a lower middle-income or a low-income country, or were not an evaluation of a RHIS strengthening intervention. Following these exclusions, the reviewers assessed the remaining articles to determine if they met the criteria above. If unsure of whether a particular article met the inclusion criteria, the reviewers included the article in the batch of articles to be reviewed by the lead authors. After this process was complete, the two reviewers compared lists and created three libraries for the lead authors to

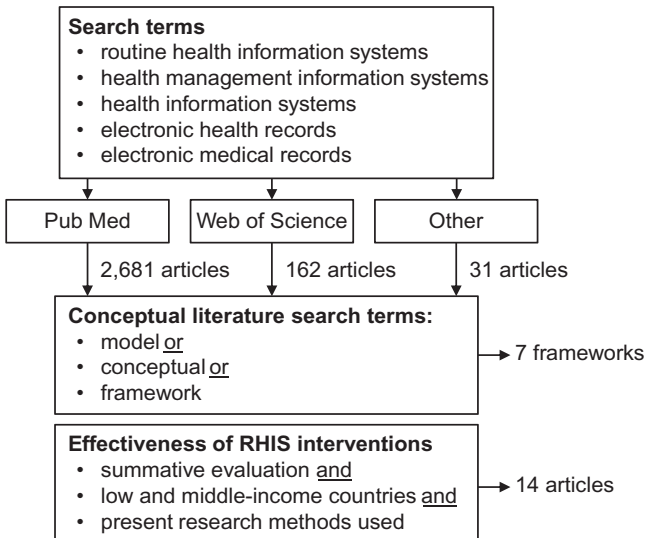


Fig. 2. Literature Search.

review: a library where both reviewers agreed on the article's applicability (14 articles), and two libraries where only one reviewer agreed on the article's applicability (21 articles). The reviewers and lead authors discussed all 35 articles and determined that 14 articles met the inclusion criteria. Fig. 2 summarizes the literature search.

DETERMINANTS OF ROUTINE HEALTH INFORMATION SYSTEM PERFORMANCE

Sources and quality of evidence: The variation in the types of RHIS discussed in the literature ranges from paper-based facility records to electronic health records. Many of the articles meeting our inclusion criteria come from the health informatics literature. These are typically geared toward the evaluation of hospital electronic health records in high-income settings. The articles presenting frameworks for evaluating HIS in developing country contexts come from the health policy and tropical medicine literature and the grey literature. One of these articles focuses specifically on RHIS (Aqil et al., 2009), while the others focus on the process of evidence-based decision making based on data from a variety of HIS components (De Savigny & Binka, 2004; Health Metrics Network, 2008; MEASURE/Evaluation Project, 2006).

Determinants of RHIS performance: As defined earlier, RHIS performance encompasses both data quality – relevance, completeness, timeliness, accuracy – and information use for decision making.

The growing attention to the field of RHIS evaluation in recent years stems in part from the rapid development and adoption of information and communications technology (ICT) and the increased recognition that RHIS interventions, if not appropriately designed and implemented, can and often do fail. As discussed in Marcelo (2010), there are many failed RHIS projects in both developing and developed country contexts (see Balka, 2003 and Littlejohns, Wyatt, & Garvican, 2003 for examples). Improving health care delivery through RHIS-based approaches can be particularly challenging in developing countries, where health systems are often under-resourced, chaotic, and corrupt (Lucas, 2008).²

The focus of recent RHIS evaluations encompasses not only technical issues – such as the number and types of indicators, and the type and complexity of the data generation architecture and decision support systems – but also behavioral and organizational issues, such as skills and

motivation to use the system and governance, leadership, and management issues (de Keizer & Ammenwerth, 2008; Yusof, Papazafeiropoulou, Paul, & Stergioulas, 2008). Box 1 presents a range of potential determinants of RHIS performance discussed in the literature we reviewed. Determinants at multiple levels are discussed, including the societal, health systems, organizational or facility, program, and health worker levels. Notice that within each level, technical, organizational, and behavioral factors are all featured.

Box 1. Underlying Factors that Might Influence RHIS Data Quality and Information Use

Societal-level factors

- Income per capita, transportation infrastructure, communications infrastructure, traditions and values, including the presence of a culture of information, corruption, regulatory environment.

Health system-level factors

- *Technical:* indicators (type and number); data collection and reporting standards; infrastructure; complexity of reporting forms; complexity of data generation architecture; software.
- *Organizational:* leadership and governance; planning processes; availability of resources; degree of integration of services and supporting management; training opportunities; management and supervision processes; incentives (both financial and nonfinancial); presence of quality improvement processes; promotion of a culture of information.

Facility- or organization-level factors

- *Technical attributes:* indicators (type and number); infrastructure; complexity of reporting forms; complexity of data generation architecture; software.
- *Organizational:* leadership and governance; planning processes; availability of resources; training opportunities; management and supervision processes; incentives (both financial and nonfinancial); presence of quality improvement processes; promotion of a culture of information.

Health program-level factors

- *Technical attributes*: indicators (type and number); infrastructure; complexity of reporting forms; complexity of data generation architecture; software.
- *Organizational*: leadership and governance; planning processes; availability of resources; training opportunities; management and supervision processes; incentives (both financial and nonfinancial); presence of quality improvement processes; promotion of a culture of information.

Health worker-level factors

- *Organizational and behavioral*: motivation to use information; skills to collect, analyze, and use information for decision making; confidence levels for RHIS tasks.
- *Health worker attributes*: age; educational attainment; experience.

Conceptual frameworks to describe RHIS performance: Table 1 summarizes seven conceptual frameworks linking RHIS to health systems performance. One framework is the *Performance of Routine Health Information System (PRISM)*, developed by Aqil et al. (2009) with support from USAID’s MEASURE Evaluation Project. PRISM consists of a conceptual framework and associated data collection and analysis tools to assess, design, strengthen, and evaluate RHIS. The PRISM conceptual framework hypothesizes that technical, behavioral, and organizational determinants (inputs) influence data collection, transmission, processing, and presentation (processes), which in turn influence data quality and use (outputs), health system performance (outcomes), and ultimately, health outcomes (impact). In their description of the PRISM approach, the authors stress the importance of “how people react and use information for problem solving or self-regulating their performance (behavioral factors)” and “organizational processes for creating an enabling environment for using and sustaining RHIS” to the success of RHIS strategies (Aqil et al., 2009). For example, an organizational factor included in the framework is the promotion of a culture of information, and individual behavioral factors include RHIS task competence and confidence, and the motivation to analyze and use RHIS information.³

Table 1. Conceptual Frameworks Linking RHIS Investments, Data Quality, Data and Information Use, and Health Systems Functioning/Performance (in Chronological Order).

Authors/Type of Health Information System	Inputs – Determinants	Processes	Outputs – RHIS Data Quality and Information Use	Outcomes – Health Systems Functioning, Health Systems Performance
Goodhue and Thompson (1995)/ Task-technology fit	Task characteristics Technology characteristics Individual characteristics Precursors of utilization: expected consequences of use, affect toward using, social norms, habit, facilitating conditions	Task-technology fit Utilization	Individual performance: effectiveness, efficiency, quality	N/A
Shaw (2002)/ CHEATS	Technical	Appropriateness of technologies; video and sound quality; ease of use; technology-specific training; reliability of technology		Clinical Human and organizational Educational Administrative Social
DeLone and McLean (2003)/ IS Success Model Applied to RHIS by Lau, Hagens, and		Information quality – completeness, accuracy, availability, timeliness, reliability System quality – functionality, performance (access,	Intention to use/use – actual system use, self-reported system use User satisfaction – user competency, user perceptions, ease of use	Net benefits – quality of care (patient safety, appropriateness and effectiveness, health outcomes), productivity (efficiency, coordination

Mutitt (2007), Benefits evaluation framework	reliability, response time), security Service quality – responsiveness of IS support	of care, net costs), service access
De Savigny and Binka (2004)/A pathway for evidence-based planning	Data cleaning, controlling, organizing, and analyzing	Actions/decisions regarding implementation of plans and systems Impact of actions/decisions Monitoring change Forecasting
MEASURE/ Evaluation (2006)/Data demand and information use framework	Data collection and analysis	Service coverage Service quality Efficiency
Hammer et al. (2007)	Perceived usefulness of information system	Information availability Information demand Information use for decision-making
	Technical – software fit with user requirements, information system supplier knowledge of health system environment; appropriateness of information system design	Effective use of information system and/or outputs

Table 1. (Continued)

Authors/Type of Health Information System	Inputs – Determinants	Processes	Outputs – RHIS Data Quality and Information Use	Outcomes – Health Systems Functioning, Health Systems Performance
<p>Health Metrics Network (2008)/ Framework and standards for country health information systems</p>	<p>Resource availability at the provincial and health facility levels Organizational and contractual mechanisms, management commitment to success Behavioral – knowledge and understanding of information system</p>	<p>Indicators Data sources Data management (data storage, processes to ensure data quality, data processing, and compilation)</p>	<p>Information products Dissemination and use</p>	

<p>Yusof et al. (2008)/HOT-Fit</p>	<p>System quality Information quality Services quality</p>	<p>System use User satisfaction Organization structure and environment</p>	<p>Net benefits – clinical practice, efficiency, effectiveness, decision-making quality, error reduction, communication, clinical outcomes</p>
<p>Aqil et al. (2009)/PRISM framework</p>	<p>Technical – complexity of reporting form, RHIS design, software, IT complexity Organizational – governance, planning, training, supervision, finances, information distribution, promotion of a culture of information Behavioral – data demand, RHIS task competence, RHIS task confidence; motivation</p>	<p>Data collection Data transmission Data processing Data analysis Data display Data quality checking Feedback</p> <p>Data quality – relevance, completeness, timeliness, accuracy Information use – for identifying problems, for considering and making decisions, and for advocacy</p>	<p>Service coverage</p>

Many of the other frameworks also stress the joint importance of technical, behavioral, and organizational factors to the success of RHIS interventions. For example, the *Information Systems (IS) Success Model*, first proposed by DeLone and McLean, focuses on measuring the success of information systems using a multidimensional model of “success” that includes information quality, system quality, service quality, intention to use, actual use, user satisfaction, and net benefits (2003).

The *IS Success Model* was developed to assess IS in general and not specifically RHIS, but a number of health informatics researchers have applied the model to the evaluation of RHIS (e.g., Lau, Kuziemsky, Price, & Gardner, 2010). Yusof, Kuljis, Papazafeiropoulou, and Stergioulas (2008) build on the *IS Success Model* in their *human, organization, and technology-fit (HOT-fit)* model. HOT-fit incorporates organizational factors, such as structure and environment, and defines net benefits as aspects of facility-based performance, including clinical practice, efficiency, effectiveness, decision-making quality, error reduction, and clinical outcomes, all aspects of health systems performance.

In addition, most of the frameworks reviewed consider the potential linkages between RHIS data quality and information use for better health systems functioning. Data quality is characterized by the relevance, accuracy, timeliness, and completeness of data. Information use is defined as decision makers explicitly considering information in policymaking, planning, management, and service delivery (MEASURE/Evaluation Project, 2006).

Table 1 also illustrates several interrelated concepts that are important to evaluating the impact of RHIS strengthening initiatives. The dimensions included in the frameworks consist of *service coverage* (i.e., service availability, service utilization), *service quality* (i.e., patient safety, adherence to provider guidelines, reduced errors, improve continuity of care, patient satisfaction), and *efficiency* (i.e., changes in resource allocation, changes in work practices, unit costs).⁴ Such outcomes might be measured using different units of analysis. Service coverage would ideally be measured at the national, regional, and district levels, service quality would be measured at the facility level, and efficiency could be measured at multiple levels.

Examination of these frameworks leads us to several conclusions. First, along with technical factors, all of the frameworks stress the importance of social and organizational factors to the success of information systems. Information systems have multiple users within an organization – for example, health workers, clerks, facility administrators, and decision makers at higher levels – and if the stresses and benefits of adopting the RHIS are

not considered from the perspective of each type of user, then the chances that the information system will improve health systems functioning will be reduced. This is a key theme of not only the frameworks we reviewed, but also in the overall literature on evaluating information systems. For example, [Berg \(2001\)](#) and [Anderson and Aydin \(2005\)](#) stress the view that complex social interactions within the organization determine the use and impact of RHIS. According to this view, understanding the dynamic social and political processes that occur within organizations as well as characteristics of individuals and the information system is required in order to predict the impact of RHIS interventions on organizational change.⁵

Second, if we wish to study data quality and information use to improve health systems functioning, we must consider whether local officials have the authority to make decisions ([MEASURE/Evaluation Project, 2006](#)). What types of decisions do local officials have authority to make, including service delivery, governance, financing, human resource management, logistics management, and so on? Who makes those decisions? The authority of local officials to make these kinds of decisions depends on their “decision space.” According to [Bossert](#), “decision space involves a complex determination of how much choice over different functions and use of funding local officials are allowed/provided from above (i.e., de jure decision space), as well as powers actually exercised in practice (de facto informal decision space)” ([Bossert & Mitchell, 2011, p. 39](#)). Their decision space over each of these functions depends on whether and how health sector responsibilities have been devolved from the central level to the local level.

Third, demand for data and information is a prerequisite to information use. For example, [Aqil et al. \(2009\)](#) treat data demand as a behavioral determinant of RHIS performance, while [DeLone and McLean \(2003\)](#) discuss the “intention to use” information as an indicator of information system success. The Data Demand and Information Use (DDIU) framework defines data demand as the value that organizations and health workers place on health information and their motivation to use it ([MEASURE/Evaluation Project, 2006](#)). As such, data demand is distinct from the use of information; it requires that (a) stakeholders and decision makers specify what kind of information they want to form a decision and (b) the stakeholders and decision makers proactively seek out that information.

Positing demand for information as important to the success of RHIS performance has a number of interesting implications. On the one hand, it implies that interventions that have the primary aim of collecting data for

reporting and that focus on technical factors with insufficient attention to organizational and behavioral factors are likely to fail in improving the use of information at the local level. Such interventions might be successful in meeting the reporting needs of bureaucrats in Ministries of Health and international organizations, and in improving data quality, but are likely to be insufficient for improving the use of information. On the other hand, it implies that broader and more complex health systems strengthening efforts that have key RHIS components can increase the value of information, and as a result, the demand for data and information. We discuss specific examples of broader health systems interventions in the next section of the chapter.

Fourth and related to the discussion above, many frameworks stress health worker motivation as key to the success of information systems. Motivation to carry out general management and service delivery responsibilities, which can influence the demand for information, as well as the motivation to collect, analyze, and use RHIS information are both cited. The stress on motivation as an important determinant of RHIS data quality and information use is very much in line with other types of reforms that aim to strengthen health systems in low- and middle-income countries. Motivation is considered to have an important influence on health worker performance, and there is a growing body of research that suggests that both financial and nonfinancial factors can be used to strengthen health worker motivation. For example, the increased use of pay-for-performance strategies is based on the premise that financial incentives for achieving service delivery targets can help improve health worker performance. Other examples of financial factors include salaries and bonuses, and examples of nonfinancial factors include prestige, organizational values, self-efficacy, pride, work conditions, and opportunities for career advancement (Franco, Bennett, Kanfer, & Stubblebine, 2004).

RHIS INTERVENTIONS FOR IMPROVING HEALTH SYSTEMS FUNCTIONING

Interventions of interest: The second analysis of the literature search assessed the evidence base on the effectiveness of RHIS interventions. We were interested in three fundamental questions: (1) is there any evidence that suggests that RHIS interventions have been effective in improving RHIS data quality, information use, and health systems functioning at the

local level, (2) which interventions have been most effective, and (3) in which situation should a particular intervention be used? The review of the conceptual literature presented in the previous section suggests a range of RHIS interventions that could be introduced in order to improve RHIS performance. They include those that address technical barriers to the use of information and communication technology, those that address organizational and behavioral barriers to data quality and information use, and broader, more complex health systems strengthening interventions that include RHIS components, including but not limited to pay-for-performance and social insurance strategies. The first two types of interventions are discussed extensively in the RHIS literature. The third type of intervention is not discussed explicitly, but we include it because health systems strengthening interventions that incorporate RHIS potentially can improve the demand for information, a key determinant of information use.

There is a range of research methods that could be used to answer the types of questions above. Empirical methods include randomized control trials and quasi-experimental designs using treatment and control groups. They also include research designs without control groups, which are limited in assessing effectiveness. Qualitative methods are also useful to study issues related to organizational and behavioral factors related to the design, adoption, and use of information systems, and the perceptions of system users in carrying out their responsibilities to collect and analyze data, and use information for decisions.

Overview of studies: Using the search strategy described in the methods section, 14 studies were judged to meet the inclusion criteria. Two more studies that might have met the inclusion criteria were not reviewed because the articles could not be accessed. We also found a systemic review of evaluation of e-Health interventions and strategies in developing countries (Blaya, Fraser, & Holt, 2010) that included EHR evaluations.

A brief description of the articles identified through the review is presented in Table 2. Overall, we found only 14 evaluations of RHIS interventions in developing country settings. These include 10 from sub-Saharan Africa, one from Eastern Europe, one from India, and one from a country that was not named to protect the identity of the respondents. All the studies evaluated interventions that included both technical and training (behavioral) components, and none of the studies evaluated broader health systems strengthening strategies that included RHIS strengthening components. Only 4 of the 14 studies assessed linkages between RHIS strengthening and health systems functioning (i.e., length of in-patient hospital stay, referrals, waiting time, etc.).

Table 2. Overview of RHIS Evaluation Studies that Met Inclusion Criteria (Including Surveillance, Electronic Medical/Health Records, Facility-Based, and District-Based HMIS).

Study, Country	Purpose of Study	Intervention/Research Design	Outcomes (Assessed Quantitatively or Qualitatively)			Results and Conclusions	Limitations
			RHIS functioning	Health system functioning	Use of services/Health status		
<i>Surveillance</i> Nsubuga et al. (2002); Tanzania	To assess the structure and performance of and support for five infectious disease surveillance systems	Introduction of HMIS and four other infectious disease surveillance and response (IDSR) systems Cross-sectional descriptive analysis at the regional, district, and facility levels in 3 of 20 regions Regions selected purposively Districts and facilities selected randomly Structured interviews and observation	Existence of surveillance system	Assessment of core activities (detection, reporting, analysis, investigation, community prevention and control, feedback) Assessment of support activities (supervision, training) Satisfaction	Use of services/Health status	None of the five IDSR systems was adequately implemented, nor adequately performed at any level; few users conducted trend analysis; no access to transport and limited paper and computer While HMIS could serve as the backbone for IDSR in Tanzania, this will require supervision, standardized case definitions, and improvements in the quality of reporting, analysis, and feedback	The assessment was incomplete, did not evaluate the role of the central Ministry of Health Indicators used to measure the performance of core activities and supports need further refinement Data quality not assessed; data use based on self-reporting
<i>Medical records</i> Littlejohns et al. (2003) and Mbananga and Becker (2002); South Africa	To assess the efficiency and effectiveness of a hospital health information system in Limpopo province	Introduction of hospital HMIS Initially a randomized-controlled trial of 24 district hospitals (12 treatment and 12 control); later modified to an externally controlled before and after design (8 treatment and 15 control)	Median time outpatient spend at hospital Length of stay Bed occupancy Number of drug prescriptions per patient Improved revenue collection Cost per patient per day Number of referrals	Little empirical evidence of benefits of HIS; some qualitative evidence that the HIS improved some activities, including efficiency in registration and admission, retrieving patient records The intervention was a failure, due to not ensuring that users understood the reasons for implementation and	Weak evaluation framework; research design had to be weakened during the study		

Table 2. (Continued)

Study; Country	Purpose of Study	Intervention/Research Design	Outcomes (Assessed Quantitatively or Qualitatively)		Results and Conclusions	Limitations
			RHIS functioning	Health system functioning		
Sivic, Gojkovic, and Husemagic (2009); Bosnia and Herzegovina	To evaluate the effects of the implementation of health information systems on patient satisfaction, cost, utilization, human errors, and wait times	Introduction of a computer-based information system in Zavidovici Medical Center Retrospective, before and after design using routine data collected via four modules: ambulatory, radiological, laboratory, business information	public health surveillance system (CDC) and interim patient monitoring guidelines for HIV care and ART (WHO)	Health system functioning	optimize effectiveness of national ART programs	
			Patient and service load: waiting time; number of human errors	Patient satisfaction	Great improvements were observed across the board: fewer patients, lower costs, shorter waiting times, fewer human errors, fewer employees Significant results on economic and professional level have been achieved, with a higher quality health care and a higher level of patient's content	Retrospective design; significant lag time between measurements; no analysis of the cost of implementing the system
Were et al. (2010); Uganda	To assess the impact of patient-specific electronic medical records (EMR)-based clinical summaries for providers taking care of HIV-positive adult patients	Introduction of EMR-based clinical summaries Time-motion techniques and provider surveys	Provider time spent with patients Length of visit Provider perception of usefulness of clinical summaries Human errors	Use of services/Health status	The average number of patients seen per day increased by three patients Time spent with each patient remained unchanged Length of patient visits decreased Provider satisfaction with clinical summaries was high	

By taking advantage of data stored in EMRs, efficiency and quality of care can be improved through clinical summaries, even in settings with limited resources

<p>Amoroso, Akimana, Wise, and Fraser (2010); Rwanda</p>	<p>To evaluate the deployment of EMR interventions on data quality and access to data and information</p>	<p>Introduction of several EMR interventions in 16 rural health centers Interventions included components to decrease errors in electronic data used by clinicians, improving transmission of CD4 results to clinicians, increasing clinician access to electronic patient summary data, and increasing detection and program enrollment of HIV positive children</p>	<p>Errors in electronic data Clinician access of patient summaries</p>	<p>Identification of pediatric patients with HIV</p>	<p>Statistically significant decrease in the proportion of completed critical CD4 lab results that did not reach clinicians; automated data quality improvement system reduced known errors by 92% by providing local data officers a tool and training to allow them to easily access and correct data errors</p>	<p>Lack of external validity</p>
<p><i>HMIS</i> Loevinsohn (1993); developing country not named</p>	<p>To examine the extent to which managers understand and are aware of the data from a new health information</p>	<p>Introduction of new HMIS that simplifies the collection of routine data from health facilities and used microcomputers to collate results</p>	<p>Indicators of skills in interpreting and manipulating HMIS data</p>	<p>Managers interviewed appeared not to use and displayed little familiarity with the data</p>	<p>Managers found to have difficulty in interpreting and analyzing HMIS data Managers interviewed appeared not to use and displayed little familiarity with the data</p>	<p>Study intended to be an assessment of data utilization and analytical skills and not an evaluation of the new HMIS; no baseline and control</p>

Table 2. (Continued)

Study: Country	Purpose of Study	Intervention/Research Design	Outcomes (Assessed Quantitatively or Qualitatively)			Results and Conclusions	Limitations
			RHIS functioning	Health system functioning	Use of services/Health status		
	system (facility-based RHIS)	Postintervention mixed methods approach, including self-administered survey questionnaire among 168 mid-level provincial health managers and municipal health officers and structured in-depth interviews among 25 program managers				they receive from the new HMIS Training managers in data analysis and use critical; data needs to be presented to managers in simple ways; further research is needed to understand how managers perceive and use data; efforts to ensure data use needs to be well integrated into the HMIS design	groups included in the study design
Braa, Heywood, and King (1997); South Africa	To evaluate district-based health and management information systems in two districts	Introduction of district-based health and management information system in two districts Case studies based on interviews and focus group discussions with clinic staff	Finding areas of duplication Staff awareness, perception and use of RHIS Coordination of RHIS Ease of use of RHIS			No evidence of use of information for decision making; little or no feedback on information sent to managers; no use of goals or objectives in planning of the services; a total of 172 forms for data collection were in use; data collection was conducted by nurses and occupied 40% of their time At one site, data was not kept centrally so analysis could not be performed A successful H & MIS must address local needs and create staff buy-in	Case study based on small number of districts (two)

<p>Heywood and Campbell (1997); Ghana</p>	<p>To discuss lessons learned from the introduction of an integrated health management information system in Ghana</p>	<p>Introduction of an integrated HMIS in 25 districts; intervention included: participatory design of planning, data collection, feedback and reporting tools; training; indicator development; development of tools for self-assessment</p> <p>A case study approach, which included "baseline and follow-up rapid appraisal surveys using a standardize methodology".</p>	<p>Information use at the district, hospital, and health facility levels</p>	<p>Marked improvement in information use at the district, hospital, and health facility levels after 10 months, but a stagnation of results four years later</p> <p>Achievements included promotion of self-reliance, improved data relevance and accuracy, strengthened supervision and support; problems identified include difficulty for identifying most appropriate institutional location of HMIS; overemphasis on process and reporting, cumbersome and time-consuming processes</p>	<p>Methods used to conduct baseline and follow-up surveys not described</p>
<p>Odhiambo-Otieno (2005); Kenya</p>	<p>To evaluate the extent to which existing district health management information systems have supported the operational management of health services at the district level</p>	<p>Introduction of district-level HMIS</p> <p>Cross-sectional mixed-methods approach, which includes questionnaires, focus group discussions, and review of literature</p> <p>Sample of 30 respondents in 3 study areas using snowball sampling</p>	<p>Training</p> <p>Adequacy of resources</p> <p>Data quality</p>	<p>Fragmentation of HMIS; mismatch between information and job functions; limited feedback</p> <p>Resources inadequate</p> <p>Poor data quality</p> <p>HMIS plagued by numerous design, operational, resource, and managerial problems</p> <p>Reliability of software found to be high, but usability found to be low</p>	<p>Descriptive, cross-sectional design</p>
<p>Lungu (2008); Tanzania</p>	<p>To investigate the reliability and usability of district health</p>	<p>Introduction of DHIS software</p> <p>Case study based on 18 health workers in</p>	<p>Reliability and usability scales</p>	<p>Reliability of software found to be high, but usability found to be low</p> <p>Mismatch between the</p>	<p>Small sample size; purposeful sampling</p>

Table 2. (Continued)

Study, Country	Purpose of Study	Intervention/Research Design	Outcomes (Assessed Quantitatively or Qualitatively)			Results and Conclusions	Limitations
			RHIS functioning	Health system functioning	Use of services/Health status		
Shabbir et al. (2010); India	To assess the impact of an electronic medical records in an eye hospital on documentation time	five districts in eastern Tanzania; workers selected purposively Data included close-ended questionnaires, semi-structured interviews, observation Introduction of an EMR system in an eye hospital Ten randomly selected optometrists documented the time they spent during consultation with both paper and EMR documentation; the time spent was documented for a total of 200 records (100 EMR and 100 paper records)	Time spent on documentation	Health system functioning	Use of services/Health status	implemented online data entry forms/reports and their respective paper-based forms/reports Software could not accommodate health data from various programs	Small sample; Hawthorne effect; did not account for seasonal changes at the clinic

Table 3. Number of Articles Included in Analysis, by RHIS Category and by Evaluation Type.

RHIS Category	Quantitative		Qualitative
	Descriptive	Controlled	
HMIS	2	0	1
Health/Medical records	1	3	6
Surveillance	1	0	0
Total	4	3	7

As seen in [Table 3](#), a wide range of research designs was used. The study with the most rigorous research design was an externally controlled study of the impact of an electronic health records system in South Africa. Four of the other six empirical studies were descriptive and seven studies were based on qualitative methods.

We also conducted an informal review (results not reported here) of the provider pay-for-performance literature to explore whether the role of HIS on the effectiveness of pay-for-performance has been evaluated. Pay-for-performance involves the “transfer of money or material goods conditional on taking a measurable action or achieving a predetermined performance target,” and information from RHIS is needed to assess and verify whether providers have achieved the target ([Eichler & Levine, 2009](#)). Despite the crucial role of RHIS to the success of pay-for-performance schemes at the district and facility levels, none of the evaluations reviewed included a careful description of the role of RHIS in the intervention. Moreover, according to a recent assessment of World Bank health, nutrition, and population projects with pay-for-performance components implemented between 1995 and 2008, none of the projects adequately documented processes used to verify whether targets were achieved ([Brenzel, 2009](#)).

KNOWLEDGE GAPS

We began with the question posed by the title of this chapter: how can RHIS improve health systems functioning in low- and middle-income countries? Based on our review of the evidence, the answer is that we do not yet know.

There are a number of challenges to evaluating the impact of RHIS strengthening on health systems performance. The first and perhaps most

significant challenge is the complexity of RHIS interventions. Our review of existing RHIS evaluation frameworks illustrates the complexity of RHIS and highlights the challenges of effectively examining the impact of RHIS interventions. Complex systems exhibit behavior or properties as a whole that may not be obvious from the behavior of the individual components. Because specific interventions target certain components of RHIS performance, their impact on overall performance is not necessarily clear. This is the likely explanation for why most examinations of RHIS performance we found in the literature focused primarily on technical and behavioral RHIS components, and not on broader, more complex health systems strengthening initiatives that incorporate RHIS components.

A second issue related to the first is that there may be multiple aims for RHIS interventions, including, for example, data quality, information use for a variety of purposes, technology acceptance, health worker motivation, and so on. In addition, the aim of some RHIS interventions might be to improve the availability of usable information at the central level, but not necessarily at the local level, often to meet national-level and global reporting requirements rather than to improve management and implementation at the local level. Coupling interventions with multiple aims and complex systems makes it challenging to detect the effect of the RHIS interventions. Evaluations of such RHIS interventions require a well-planned and rigorous methodology that is so far mostly lacking in the existing literature. We will discuss general methodological issues subsequently.

A third issue focuses on the timing of RHIS interventions and their evaluation. There is evidence in the literature from the United States that it takes a significant period of time, often several years, before HIS interventions begin to achieve the performance gains they were intended to achieve (Borzekowski, 2009). In fact, organizations may exhibit a period of decreased performance immediately following the introduction of an information systems intervention. Moreover, when information systems are introduced, users may be uncertain whether and how routine data may be of use to them to carry out their responsibilities. Their perceptions of how routine information might be useful may change over time. Because of these factors, cross-sectional examinations of RHIS interventions are likely to fail to detect their long-term impact. A secondary issue related to the time it takes for an RHIS intervention to achieve its goals is the sustained effort needed to implement the intervention. If the intervention does not show short-term performance gains, it may be prematurely abandoned.

A fourth issue is the concept of “information use” and how it relates to RHIS. A clear theme that runs through the RHIS literature is the desire to support and achieve evidence-based decision making with information provided by an RHIS. To achieve this goal, the RHIS must provide high quality and relevant information for decision makers, which is in part a function of what information the decision makers demand, but the question arises as to how information from the RHIS can be expected to influence the types of decisions being made. In other words, at what point does the RHIS end and the decision process begin? There is an entire literature examining the decision-making process, of which the use of information is only one piece. Individuals make decisions based on a variety of other factors in addition to information, which makes the evaluation of an RHIS on the basis of decision making problematic. One could argue that having useful information is a necessary but not a sufficient condition for effective decision making.

If the use of information is considered an indicator of RHIS functioning, other questions arise. How should the information provided be used? On what basis do we evaluate whether it was used for decision making, rather than to support individual agendas? Who should use it, at what level, and for what purposes? These are hard questions to answer, and they are influenced by factors outside of the RHIS. One example of such a factor is the level of decentralization. Do local managers and staff have the autonomy to make decisions, and is the information provided by the RHIS useful for such decisions, or is the RHIS designed for central-level decisions?⁶

A related issue is how well the design of the RHIS separates data from the information that the system generates. An information system that stores data separately from the information needs of its users is likely to be flexible enough to generate a variety of information outputs based on user queries. On the other hand, a system that is designed to store data in relation to specific information needs or reporting requirements is generally not flexible enough to meet varying user information needs that may arise, particularly in a decentralized context. Put another way, an information system that is designed in a vertical fashion to meet the needs of users at a central level may not have the flexibility to meet information needs at the district or local levels. Separating the data collection, storage, and management from the information they will be used to generate allows the flexibility to meet the information needs of varying users.

This last point raises the issue of how “information use” can affect data quality, and vice versa. Simply put, poor-quality data lead to low-quality

information, which is less valuable for effective decision making, while high quality data can lead to high quality and useful information for improved decision making. Here we see the interaction of technical and human or behavioral components of the system (Berg, 2001). User demand for useful information for decision making can lead to improvements in data quality. Likewise, useful information can lead to its increased use for decision making. This process of mutual transformation of an information system complicates efforts to evaluate its performance.

A fifth issue is the methodological approach used to evaluate RHIS interventions. Randomized-controlled trials may be considered the gold standard design, but they are practically difficult to implement in RHIS settings (Littlejohns et al., 2003). Case studies based on qualitative methods are useful to assess whether users adopt information systems and whether and how information is used for decision making, but cannot quantify the benefits on health systems functioning. Clearly, a variety of methods are available to examine RHIS interventions, but given the issues of complexity and the potential time lag between implementation and the realization of benefits, the most rigorously controlled approaches are particularly desirable. In particular, prospective, longitudinal designs, ideally with treatment and control groups, are needed, and would be major improvements in the approach to evaluating RHIS.

In summary, despite the potential role that RHIS can play in improving the functioning of health systems, there are numerous knowledge gaps on the ability of RHIS to improve health systems functioning and performance. We also have little knowledge of the benefits of specific interventions targeted at certain aspects of RHIS. Most of the literature we reviewed examined technical and training interventions, while none examined broader managerial and financial strategies in which RHIS plays a critical role. The cross-sectional and quasi-experimental designs of the literature further complicate the current state of knowledge.

RECOMMENDATIONS

Although improved health information is viewed as critical to the success of health systems strengthening strategies and interventions, including those related to moving away from parallel systems and toward supporting country-owned, integrated national systems, our literature review demonstrates that there is limited evidence on which types of information systems interventions work, and which do not. This dearth of evidence is not

surprising, as in the context of low- and middle-income countries, HIS are predominantly viewed as a source of data for monitoring and evaluation, not as a topic of health systems research ([Alliance for Health Policy and Systems Research, 2008](#)).

A concerted effort is needed to build the evidence-base on the costs and benefits of varying approaches to strengthen RHIS. RHIS are intended to improve the functioning of health professionals and organizations in managing and delivering health care services. Given the potential benefits to both patients and health professionals, it is imperative to assess the effectiveness of RHIS projects, particularly in the context of low- and middle-income countries, where health sector resources are more limited than in high-income countries. Otherwise, these projects may not be funded, and as result, patients may be the ones who ultimately lose out.

One important first step to growing the evidence base would be to develop an RHIS evaluation research agenda. Recommended components of a research agenda could include the following elements:⁷

- Refinement of existing conceptual frameworks for evaluating RHIS interventions. While there are a number of excellent evaluation frameworks available, most focus on the determinants of the availability of quality data and information use, but do not always clearly depict the linkages at play between data quality, use of information, and health systems functioning at various health system levels (facility, district, regional, national). Existing evaluation frameworks could be refined so that they more clearly show the causal pathways at work between technical, behavioral, and organizational determinants, demand for information, use of information, and service delivery. Such frameworks could be useful not only for guiding evaluations of RHIS interventions, but also for designing RHIS strengthening strategies.
- Research on the technical, organizational, and behavioral determinants of enhanced demand for information, improved data quality, improved information use, and the role of RHIS in improving health systems functioning. While this type of formative research was not reviewed for the present paper, previous studies have found that there is relatively little empirical research that links potential RHIS determinants and drivers and actual performance ([Alliance for Health Policy and Systems Research, 2008](#); [Aqil et al., 2009](#)). Of particular interest is research on the role of organizational reforms and incentives that can influence the motivation of district and facility managers to collect, analyze, and use information. Again, a better understanding of these issues could also be useful in

improving the design of health systems strengthening interventions that incorporate RHIS components.

- Research on the costs and effectiveness of strategies and interventions aimed to improve health systems functioning at the local level through improved RHIS data quality and information use. As mentioned earlier, all of the studies meeting our inclusion criteria are assessments of the impact of technical interventions. We did not identify any studies that assess the effects of organizational or other types of health systems strengthening reforms, nor did we identify any economic evaluations of the cost-effectiveness of alternative strategies. Moreover, most of the research designs we reviewed are inadequate to attribute changes in health systems functioning to RHIS interventions. Given the limited evidence base to date, prospective impact studies and economic evaluations based on experimental and quasi-experimental research designs should receive high priority. Retrospective case studies based on qualitative and quantitative research designs can also be useful.
- Work on summarizing study results and translating important findings for decision makers responsible for the design of health systems strengthening strategies that incorporate RHIS components.

These topics could be part of a research agenda that concentrates solely on RHIS strengthening interventions, or could be part of a broader research agenda on health systems strengthening, in order to improve understanding of the role of RHIS. Regardless of which approach is taken, further work is needed to develop the research agenda, and build consensus around it among health systems researchers and producers and users of information at the local, national, and global levels, and international organizations and donors. Also critical is the mobilization of resources to support systematic research in this area.

NOTES

1. Sometimes referred to as health management information systems.
2. However, it has been observed that the adoption of information systems within the health care sector in high-income countries such as the United States has lagged behind other sectors.
3. Four survey instruments and associated sampling procedures and analysis guidelines were developed to assess RHIS performance along the dimensions of the framework, including processes and technical, behavioral, and organizational determinants at the facility, district, and country levels. The reliability and validity of the PRISM instruments have been supported in [Hotchkiss, Aqil, Lippeveld, and](#)

Mukooyo (2010) using facility-based survey and record review data from Uganda. Assessments based on the PRISM approach have been conducted in Asia, Africa, and Latin America (Aqil et al., 2009).

4. For an excellent review of systematic reviews of health information system studies, most of which come from high-income countries, see Lau et al. (2010).

5. In addition to this theory, there are two other general types of theories that appear in the literature: (1) technology as an external force and (2) system design as determined by user information needs. The first type of theory views the information system as an exogenous force that leads to the change in the behavior of individuals and their work, and ultimately to changes in the organization. Studies based on this theoretical perspective tend to minimize the role of organizational characteristics in the success of RHIS strengthening initiatives. The second type of theory takes a very different perspective. It views the design of information systems as an endogenous factor that is determined by the information needs of managers, clinicians, and other users. See Anderson and Aydin (2005) for a review of these theories.

6. Decentralization of government-run health systems poses a critical challenge to ensuring the quality and effectiveness of RHIS in many developing countries (Nsubuga et al., 2006). A number of factors may be in play. First, RHIS may not perform well in a decentralized context if local health managers and staff lack the capacity to carry out devolved RHIS functions previously carried out by national level staff, or if there is low demand for health information at the local government level. Second, demand for information may be limited if RHIS is designed for centralized, disease-focused, and often fragmented programs, and if RHIS is unaligned with the needs of local managers and staff. This mismatch between the availability of information and user needs can be further exacerbated if efforts to reform RHIS are “data led” rather than “action led,” and as a result, serve the interests of bureaucrats at the national and international levels rather than front-line health workers (Heywood & Campbell, 1997). Third, other health system factors, such as limited local resources, low health worker motivation, inadequate transportation and communication, and weak accountability, can also limit RHIS system performance.

7. The structure of this section draws on Rowe, de Savigny, Lanata, and Victora (2005), an excellent literature review on strategies to improve health worker performance in low-resource settings.

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SECTION 2
HIT POLICY WITHIN
INDIVIDUAL COUNTRIES

A DUTCH AND AMERICAN COMMENTARY ON IT IN HEALTH CARE: ROUNDTABLE DISCUSSIONS ON IT AND INNOVATIONS IN HEALTH CARE

Grant T. Savage and Leo van der Reis

ABSTRACT

Purpose – This chapter reports on experts' perspectives on health information technology (HIT) and how it may be used to improve health care quality and to lower health care costs.

Design/methodology/approach – Two roundtables were convened that focused on how to best use HIT to improve the quality of health care while ensuring it is accessible and affordable. Participants drew upon lessons learned in the Netherlands, the United States, and other countries.

Findings – The first roundtable focused on the use of (1) electronic health records (EHRs) by health care providers, (2) cloud computing for EHRs and health portals for consumers, and (3) data registries and networks for public health surveillance. The second roundtable highlighted (1) the rapid growth of personalized medicine, (2) the corresponding growth and

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sophistication of bioinformatics and analytics, (3) the increasing presence of mobile HIT, and (4) the disruptive changes in the institutional structures of biomedical research and development.

Practical implications – Governmental sponsorship of small pilot projects to solve practicable health system problems would encourage HIT innovation among key stakeholders. However, large-scale HIT solutions – developed through small pilot projects – should be pursued through public–private partnerships. At the same time, governments should speed up legislative and regulatory procedures to encourage adoption of cost-effective HIT innovations.

Social implications – Mobile HIT and social media are capable of fostering disease prevention and encouraging personal responsibility for improving or stabilizing chronic diseases.

Originality/value – Both health services researchers and policy makers should find this chapter of value since it highlights trends in HIT and addresses how health care quality may be improved while costs are contained.

Keywords: Cost effectiveness; electronic health records; health information technology; health innovations; quality of care

The Netherlands Consulate General in San Francisco sponsored two roundtable discussions on IT and innovations in health care for Edith Schippers, the Minister of Health, Welfare, and Sports, and her advisors on January 12 and 13, 2012. Cisco Systems hosted the first of these two events, the Roundtable Discussion on Innovations in Healthcare Models and the Role of Information Technology, at its Executive Briefing Center in San Jose, CA. Consul General Bart van Bolhuis hosted the second event, The Roundtable on Innovations in Healthcare, at his residence in San Francisco, CA. The authors were invited participants; for a list of all the participants, please see the appendix.

The roundtables focused on how the Netherlands can best use IT and related innovations to improve the quality of health care while ensuring it is accessible and affordable, drawing upon lessons learned in the Netherlands, the United States, and other countries. The first two sections of this chapter highlight the key questions and observations from the roundtables, respectively, on “Innovative Healthcare Models and the Role of IT” and

“Innovations in Healthcare.” The third section provides a brief commentary that reflects upon the challenges and opportunities for health care IT in both the Netherlands and the United States.

INNOVATIVE HEALTH CARE MODELS AND THE ROLE OF INFORMATION TECHNOLOGY

During the roundtable discussion, participants addressed the following topics:

- What are the best practices in IT pertaining to health care models/systems?
- How can IT be best leveraged in providing quality health care that is also cost effective?
- What role should the government play to stimulate IT innovations (adoption of electronic health records)?

Best Practices

Participants highlighted several best practices in the use of health information technology (HIT). This discussion had three foci on the use of (1) electronic health records (EHRs) by health care providers, (2) cloud computing for EHRs and health portals for consumers, and (3) data registries and networks for public health surveillance.

EHRs

To offset the large investment that EHRs require, leading health care organizations focus on improving the use of IT by re-engineering clinical workflows to take advantage of electronic versus paper-based processes. In addition, when implementing EHRs, organizations customize the user interfaces using templates, drop down menus, etc. to optimize the health providers' experience. Moreover, leading health care organizations are adopting decision support features for EHRs that facilitate health providers' monitoring of chronic conditions and remind them about preventive health measures. Lastly, a best practice for public and private insurance is to incentivize EHR adoption by linking quality improvement and cost reductions with payments and cost sharing, respectively.

Cloud Computing and Health Portals

New business models for HIT have emerged because of cloud computing. For health providers and consumers, the payment model often consists of a free set of features, with revenue earned from targeted advertisements and sale of aggregated data. For health providers, a current example is Practice Fusion (www.practicefusion.com), which offers an EHR at no cost to the medical practitioner. For consumers in the Netherlands and Western Europe, Microsoft uses a similar business model for HealthVault (www.healthvault.me), a cloud-based health portal. These alternative business models and delivery platforms use either private or public cloud computing and rely on, or incorporate, social media.

Public Health Surveillance

The growing and widespread adoption of EHRs by health providers creates the opportunity to report adverse events in real time via health information networks to drug and medical device registries. The mining of these data should improve patient safety and alert both manufacturers and government agencies of the benefits and the hazards of both label and off-label use of pharmaceuticals (Brajovic, Piazza-Hepp, Swartz, & Pan, 2012). Moreover, public health surveillance of flu, HIV, and other infectious disease epidemics would be significantly enhanced, allowing more rapid responses to contain and prevent their spread (Fairchild & Bayer, 2011). Lastly, EHRs and health information networks potentially enable public health surveillance to identify small geographic areas in risk of chronic diseases (Noble, Smith, Mathur, Robson, & Greenhalgh, 2012).

Leveraging IT for Quality and Cost Effectiveness

Participants identified several ways that IT could be better leveraged to improve health care quality and cost effectiveness. These recommendations were focused on strategic approaches that would address some of the most costly aspects of health care. Additionally, many of these insights were based on the observation that affordability and quality of care cannot be separated (Bodenheimer & Fernandez, 2005). Eliminating unnecessary, especially duplicative, care services is one area in which health IT can excel. To do so, however, existing EHRs should be optimized around clinical workflows and connected to health information exchanges or networks (Lee et al., 2012).

Moreover, because lifestyles are a significant factor contributing to the costs associated with chronic diseases (Bogaert & Schrier, 2011), many

participants advocated using mobile HIT and social media to foster disease prevention (Lindstrom et al., 2010) and to encourage personal responsibility for improving health outcomes.

Lastly, another set of recommendations focused on ways to reduce the costs of EHRs. On one hand, establishing a national standard for a personal ID that would be recognized across all EHRs and health information networks would eliminate the costly problems of fragmented health records, which not only lead to unnecessary tests and treatments, but also lead to active and latent medical errors (Bourgeois, Olson, & Mandl, 2010). On the other hand, moving EHRs to cloud computing (while ensuring both network dependability and security) would reduce the costs and inefficiencies associated with client-server models and extend both clinical and public health capabilities (Lenert & Sundwall, 2012).

Stimulating IT Innovations

Participants emphasized two themes when discussing the role government should play in stimulating IT innovations. The first theme was to look outside the current use of information technology within the health care system and its processes. Specifically, participants advocated that the Dutch and American governments should develop a vision for their health care systems, prioritize their needs, and then turn to health IT enterprises to help fulfill those visions. The second theme complemented the first by emphasizing the importance of collaborating with key stakeholders. On one hand, governmental sponsorship of small pilot projects to solve practicable health system problems would encourage IT innovation among key stakeholders. On the other hand, large-scale HIT solutions – developed through small pilot projects – should be pursued through public–private partnerships. For example, private health insurers and health providers would be key stakeholders for any EHR-based solution to both improve health care quality and lower care costs.

INNOVATIONS IN HEALTH CARE ROUNDTABLE

The participants addressed the following topics during the roundtable discussion:

- What technological trends do you see in health care?

- How can the government stimulate technological innovations in health care?
- With the applications of new technologies, how can we keep health care accessible and affordable?

Technological Trends in Health Care

Participants identified four important technological trends: (1) the rapid growth of personalized medicine, (2) the corresponding growth and sophistication of bioinformatics and analytics, (3) the increasing presence of mobile HIT, and (4) the disruptive changes in the institutional structures of biomedical research and development.

Personalized Medicine

Participants agreed that the rapid growth in personalized, genomic-based medicine was an important trend that would potentially have two interesting impacts. On the one hand, personalized medicine for critically ill individuals will increase initial diagnostic and treatment costs, which is clearly the trend in the treatment of cancer (Holstein & Hohl, 2012; Meropol & Schulman, 2007; Schnipper, Meropol, & Brock, 2010). On the other hand, personalized medicine has the potential to decrease the overall costs of treating many illnesses. One way is through early detection, when diseases are easier to treat effectively (Greeley et al., 2011; Van Vlaenderen et al., 2009). Another way is by improving the quality of treatment, from non-specific drugs to specific agents and immunotherapy approaches, thus extending not only survival rates but also the quality of life (Keogh, 2012). A third way is by significantly improving the identification of those at risk for high-cost illnesses – such as cancer and diabetes – and thus improving the targeted prevention of disease (Sullivan, Garrison, Rinde, Kolberg, & Moler, 2011; Vogelzang et al., 2012). However, to achieve these potential benefits, personalized medicine will require large-scale comparative effectiveness research (Cohen, Wilson, & Manzillo, 2012; Postma et al., 2011).

Bioinformatics and Analytics

Along these lines, participants also noted that large-scale, multisite informatics initiatives (Rein et al., 2012) are of increasing importance. Indeed, the growth of personalized medicine has relied on the data mining and analytic techniques developed within the bioinformatics field; now this field is gaining additional power through the application of cloud computing (Grossman & White, 2012).

Mobile HIT

As noted by the previous roundtable participants, mobile health IT applications are increasingly being used to reduce costs and improve the quality of care (Lie, Mowry, & Nettle, 2008; Vigoda, Rothman, & Green, 2011). For example, chronic disease management is significantly enhanced with the use of mobile HIT, improving both health care provider coordination and patient self-management (Fitzsimons, Normand, Varley, & Delanty, 2012).

Biomedical R&D

Lastly, participants paid special attention to another notable trend: Between 2001 and 2011, the largest pharmaceutical companies had alarming levels of failure in moving internally sponsored research and development of drugs from Phase 1 to Phase 2, and from Phase 2 to Phase 3 clinical trials. Hence, since 2008, over 50% of large pharmaceutical company R&D has been outsourced (Arrowsmith, 2012). As a result, research universities have taken on a much larger role in the discovery of new drugs and devices (Musselwhite et al., 2012). However, the lack of venture capital investments for these promising technologies has artificially reduced the development of commercial products (Arrowsmith, 2012; Soleimani & Kharabi, 2010).

Stimulating Technological Innovations

Not surprisingly, participants recommended that governments should continue investing in innovations and forging policies that encourage such investments, recognizing that risk aversion currently is limiting venture capitalists' investments. For example, both the Dutch and the American governments could further expand the role of bioinformatics through public-private partnerships.

On a related note, many participants focused on ways to streamline, recalibrate, and improve government regulation of health innovations. For example, governments should speed up legislative and regulatory procedures to encourage adoption of cost-effective innovations. (Note: Currently there is a four-year window to show effectiveness in the Netherlands.) Specifically, participants recommended revising the accelerated development procedures for medical innovations, both to reduce costs and improve their accessibility.

Lastly, echoing recommendations from the previous roundtable, governments should consider the needs for health care improvement and match incentives and priorities with those needs. For example, as in the United States,

the government in the Netherlands should provide HIT adoption and “meaningful use” incentives to stimulate changes.

Keeping Health Care Affordable and Accessible

The participants underscored the difficulties in keeping health care affordable and accessible while also stimulating innovation. Because medical technology typically drives health care costs, many participants recommended the government should focus on cost controls for health care.

Participants advocated at least three approaches for controlling costs. One approach is to ensure that the cost-benefit of medical innovations is adequately demonstrated, e.g., via comparative effectiveness research, before governmental adoption and payment for such innovations. Another approach is to create health care system cost reductions through HIT and organizational innovations. The government, under this approach, should encourage not only the meaningful use of EHRs, but also the reorganization of care to improve clinical workflow and to redirect patients to centers of clinical excellence. Lastly, several participants recommended that the government limit health care therapeutic technologies for those who cannot benefit, i.e., those with advanced terminal illnesses. Such rationing of care services requires not only monitoring the effectiveness of treatments for those with terminal illnesses – a health IT application – but also engaging health providers in difficult conversations with patients and their families.

In closing, several participants raised the need for cost savings from innovations to be preserved through more sophisticated government pricing. For example, the government should calculate cost savings to include labor and productivity gains. These savings would include re-entry into the productive workforce, as well as savings from reducing personal health outlays such as transportation, family leaves, and absenteeism. Patient partnerships are needed to identify such savings.

THE CHALLENGES AND OPPORTUNITIES FOR HEALTH CARE IT IN THE UNITED STATES AND THE NETHERLANDS

For the United States and the Netherlands, there are both shared and different challenges and opportunities for deploying information technology

to improve the quality of care while reducing its costs. Clearly, both countries have developed policies that promote the widespread adoption and use of EHRs by health care providers. On one hand, because of its small size and relatively concentrated population centers, the Netherlands may be able to exploit the benefits from cloud computing, mobile HIT, and bioinformatics more quickly and at lower costs than the United States. On the other hand, the United States has a world-class set of research universities that may be better able to exploit public–private partnerships to boost the development and commercialization of both HIT and medical innovations. Lastly, both countries would benefit from investing in HIT to engage in more extensive comparative effectiveness research and public health surveillance.

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APPENDIX: ROUNDTABLE ATTENDEES*Innovative Health Care Models and the Role of Information Technology*

On Thursday, January 12, 2012, the Netherlands Consulate General in San Francisco, in collaboration with Cisco Systems, sponsored a roundtable discussion on innovative health care models and the role of IT. Participants representing the Netherlands included:

Edith Schippers, Minister of Health, Welfare and Sports (HWS)
Herbert Barnard, Director, International Affairs, HWS
Peter Bootsma, Counselor, HWS
Roelof Janssens, Press Secretary, HWS
Peter Leeftang, Head, Innovation and Availability Medical Products, HWS
Bart van Bolhuis, Consul General in San Francisco
Marc Nellen, Office for Science and Technology, Consulate General in San Francisco

Other, invited participants, included:

Eric Claassen, Professor for Technology Transfer in Life Sciences, Erasmus University
Niels Greidanus, Chief Executive Officer, The Patient Safety Company
Carl Janssen, Director, Business Unit Oncology, Pfizer
Lee Nuttal, Regional Manager, Managed Markets, Pfizer
André Piso, Lead, Western Europe Health, Microsoft
Murray Ross, Director, Institute for Health Policy, Kaiser Permanente and Vice President, Kaiser Foundation Health Plan, Inc.
Helen Routh, Vice President and General Manager, Enterprise Imaging Informatics, Philips Healthcare
Grant T. Savage, Professor of Management and Co-Director, Healthcare Leadership Academy, University of Alabama at Birmingham
Debra Sloane, Manager, Healthcare Business Development, Cisco Systems
Peter J. van der Spek, Professor and Head, Department of Bioinformatics, Erasmus MC
Ivo Struijk, Director, Corporate Affairs, GlaxoSmithKline BV
Larisa Tsvetkova, Market Access Manager, Biogen Idec

Innovations in Health Care

On Friday, January 13, 2012, the Netherlands Consulate General in San Francisco sponsored a luncheon and roundtable discussion on innovations in health care. Participants representing the Netherlands included:

Edith Schippers, Minister of Health, Welfare and Sports (HWS)
Herbert Barnard, Director, International Affairs, HWS
Peter Bootsma, Counselor, HWS
Roelof Janssens, Press Secretary, HWS
Peter Leeftang, Head, Innovation and Availability Medical Products, HWS
Bart van Bolhuis, Consul General in San Francisco
Anne Donker, Senior Economic Officer, Consulate General in San Francisco
Marc Nellen, Office for Science and Technology, Consulate General in San Francisco

Other invited participants, included:

Gregg Alton, Executive Vice President, Corporate and Medical Affairs, Gilead Sciences
Eric Claassen, Professor for Technology Transfer in Life Sciences, Erasmus University
Marcel J. Gerritsen, Director, BPRA, and Political Advisor, Dutch Vaccines Group
Johan G. Hanstede, Chairman, Dutch Vaccines Group, and Director, DutchCC
Herbert Heyneker, Advisor, Thuja Capital
Carl Janssen, Director, Business Unit Oncology, Pfizer
Clay Johnston, Associate Vice Chancellor of Research and Director, Clinical and Translational Science Institute, University of California, San Francisco
Gail Maderis, President and Chief Executive Officer, BayBio
Jan Paul Muizelaar, Professor and Chair of Neurological Surgery, School of Medicine, University of California, Davis
Lee Nuttal, Regional Manager, Managed Markets, Pfizer
Grant T. Savage, Professor of Management and Co-Director, Healthcare Leadership Academy, University of Alabama at Birmingham
Peter J. van der Spek, Professor and Head, Department of Bioinformatics, Erasmus MC
Ivo Struijk, Director, Corporate Affairs, GlaxoSmithKline BV

Larisa Tsvetkova, Market Access Manager, Biogen Idec
Leo van der Reis, Consulting Professor, University of Alabama at Birmingham
Laura van 't Veer, Angela and Shu Kai Chan Endowed Chair in Cancer
Research, University of California, San Francisco
Marika Zwienenberg-Lee, Assistant Professor of Pediatric Neurological
Surgery, School of Medicine, University of California, Davis

ASSESSING HEALTH INFORMATION TECHNOLOGY IN A NATIONAL HEALTH CARE SYSTEM – AN EXAMPLE FROM TAIWAN

Chunhuei Chi, Jwo-Leun Lee and Rebecca Schoon

ABSTRACT

Purpose – The purpose of this article is to investigate one core research question: How can health information technology (HIT) be assessed in a national health care system context?

Design/methodology – We examine this question by taking a systematic approach within a national care system, in which the purpose of HIT is to contribute to a common national health care system's goal: to promote population health in an efficient way. Based on this approach we first develop a framework and our criteria of assessment, and then using Taiwan as a case study, demonstrate how one can apply this framework to assess a national system's HIT. The five criteria we developed are how well does the HIT (1) provide accessible and accurate public health and health care information to the population; (2) collect and provide population health and health care data for government and researchers to analyze population health and processes and outcomes of health care services;

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(3) provide accessible and timely information that helps to improve provision of cost-effective health care at an institutional level and promotes system-wide efficiency; (4) minimize transaction and administrative costs of the health care system; and (5) establish channels for population participation in governance while also protecting individual privacy.

Findings – The results indicate that Taiwan has high levels of achievement in two criteria while falling short in the other three. Major lessons we learned from this study are that HIT exists to serve a health care system, and the national health care system context dictates how one assesses its HIT.

Originality/value – There is a large body of literature published on the implementation of HIT and its impact on the quality and cost of health care delivery. The vast majority of the literature, however, is focused on a micro institutional level such as a hospital or a bit higher up, on an HMO or health insurance firm. Few have gone further to evaluate the implementation of HIT and its impact on a national health care system. The lack of such research motivated this study. The major contributions of this study are (i) to develop a framework that follows systems thinking principles and (ii) propose a process through which a nation can identify its objectives for HIT and systematically assess its national HIT system. Using Taiwan's national health care system as a case study, this paper demonstrated how it can be done.

Keywords: Health information technology; health information technology assessment; Taiwan; national health care system; national health insurance; national health information system

INTRODUCTION: HEALTH INFORMATION TECHNOLOGY AND ITS ROLE IN A NATIONAL HEALTH CARE SYSTEM

Information technology has experienced exponential progress during the last two decades. Most significantly, the acceleration of faster computing and high capacity storage, coupled with wired or wireless online transmissions and access of information, are making massive amounts of data and information easily accessible – at any time in most places in the world. If executed well, these advances in information technology present enormous

opportunities for revolutionizing health care systems at all levels, from national to local systems to individual provider institutions. New information technology can profoundly change the way health care is organized and delivered, with great potential for improving quality, access, and production efficiency of health care, while the availability of massive data could generate rich information on improving national system efficiency and equity in health care.

The purpose of this article is to investigate one core research question: how can one assess health information technology (HIT) in a national health care system context? To begin this inquiry, we assume that the purpose of HIT is to contribute to a common national health care system's goal: to promote population health in an efficient way. We systematically examine this question within a national care system context, with the goals of a national health care system serving as the guiding principle for implementation of HIT. Under this approach, we assert that subsystems under the national health care system function to contribute to the same overarching national goals. In the absence of a national health care system (such as the United States), or in a country where the government does not take initiative to implement uniform, system-wide HIT, our framework will not be applicable. Further, our framework is based on the normative values of communitarian ethics and self-determination at the community level. Societies, researchers, and policy makers that do not subscribe to this normative value may advocate for or develop a health care system – or nonsystem – that deviates from our assumptions. For example, in a market-oriented health care system like that of the United States, its subsystems such as individual hospitals or insurers may not always serve the main system's goals. Thus this framework will not be applicable.

Following our normative assumptions, the use of HIT by regional or local government health agencies and individual providers should contribute toward achieving the same national goals. We recognize, however, that individual provider institutions may likely have other goals for utilizing HIT, such as improving clinical competencies, outcome quality, patient communication, or cost control. These subsystems' goals should be consistent with or contribute to the national health system's goals.

Our approach to this inquiry is to introduce a framework of assessment and develop the foundation of this framework, which is the Phase I assessment. This framework allows for a systematic, yet context-appropriate approach for assessing HIT in a national context, which should be comprised of three main phases. Before initiation of the first phase, the first step is to identify the general goals of a national health care system.

Based on these goals and the assumption that HIT is utilized as a tool to meet a national health care system's goals, criteria for assessment are developed. In Phase I, the criteria are more broadly framed without being quantifiable. Using primarily qualitative assessment, this phase seeks to examine components such as: *Does the health care system have a specific type of health information technology? Does this technology align with the health care system's goals?* In Phase II, criteria are operationalized into quantifiable indicators, which will include most outcome measurements directly contributing to the health care system's goals. Assessment for this Phase will be based on quantitative measurement and analysis, and the result of such assessment will generate quantitative indicators, such as percentages achieved. Phase III is based on the results of Phase II, incorporating costs of HIT into the assessment. Assessment methods for Phase III include cost-effectiveness analysis, cost-utility analysis, and cost-benefit analysis. Further, an important component in Phase III is to assess the equity of accessibility to HIT within the national context. Results of this assessment will generate ratios of cost effectiveness, cost utility, or cost-benefit, as well as the distribution of HIT and its benefits among the population, which will be the foundation for policy makers to decide whether and which HIT should be given higher priority. Due to the limitation of data availability, we will focus on Phase I assessment in this study, hence our assessment is qualitative in nature.

In the Phase I assessment, while no quantifiable outcome may be generated, it sets the critical foundation for Phases II and III that will generate measurable results and readily actionable policy recommendations. This is because at Phase I, researchers or policy makers (especially a ministry of health) will need to identify its values, health system goals, and the goals to which that HIT will contribute. As such, Phase I is not only qualitative in nature, but strongly normative and country specific. Once those normative parameters are determined, Phases II and III are technical, and researchers and policy makers can take a relatively straightforward engineering approach. Given this nature, our proposed criteria should not be regarded as rigid universal criteria. Rather, it is an example based on values common to nations that have implemented a universal national health insurance (NHI) system or national health services (NHS) systems. Researchers and policy makers who examine our framework should focus on the principles and processes it demonstrates, rather than its specific criteria.

This investigation uses Taiwan's national health care system as a case study, and critically assesses its application of HIT by using explicit criteria

we developed. While our study is based on one national health care system, our main purpose is to demonstrate how the assessment process and framework we established can be applied to any health care system's HIT. In our examination of Taiwan, we are simultaneously focusing on Taiwan's unique health care and social-economic context, while also constantly considering potential implications for other national health care systems. Using this approach, it is our hope that results of our study can generate lessons applicable beyond Taiwan's border. Because there are still very few macro system-wide assessments of HIT in the published literature, we also hope this paper can stimulate researchers and policy makers to take on system-wide assessments of their own country.

To begin this inquiry, we must first define what HIT is. Then, we can present our assessment method – including identification of a national health-care system's goal and developing criteria for assessing the implementation of HIT in a national health care system. Using Taiwan as a case study, we briefly introduce the health care system and discuss the development and implementation of new HIT during the last two decades. Finally, we summarize our findings and draw lessons learned from this study that are helpful for researchers and policy makers who are interested in planning, implementing, or assessing HIT in a national health care system.

HEALTH INFORMATION TECHNOLOGY

In this study, we define HIT as any information systems that are being implemented to promote population and personal health, and in the financing, organization, production, delivery, and research of health care. This includes hardware, software, institutions, and personnel. Hardware includes computers (from tablet computers to super computers), servers for connectivity and wired or wireless networks, and end user devices, communication devices, and data storage and retrieving devices. Software includes examples such as computer programs and operating systems for any hardware to function, knowledge and skills of HIT, and all health related information. Institutions include laws, regulations, policies, and agencies that are gathering, organizing, providing, regulating, monitoring or governing HIT, and educating and training personnel on how to collect, assemble, retrieve, analyze, and use HIT. Personnel of HIT include anyone who is involved in collecting, organizing, analyzing, providing, regulating, or governing HIT, as well as researchers and end users of HIT.

The World Health Organization (WHO) defines five domains for health information: health determinants, health system inputs, health system outputs, health system outcomes, and health status (WHO, 2005). In this study, we shall focus primarily on the latter four domains, mainly because the HIT relevant to the first domain of health determinants is still in its infancy and the scope is too big to be manageable for this manuscript.

METHOD OF ASSESSMENT

In this section we discuss our method of assessing HIT in a national health care system by developing our framework of assessment. The foundation of this framework is based on a principle found within the systems thinking approach. That is, all subsystems' goals should serve to achieve the goals of the main system (Checkland & Scholes, 1993, pp. 18–27). In this approach, we consider the national health care system as the main system, and HIT as a subsystem. Thus the goal of HIT is to serve and contribute to the national health care system's goals. Following this principle, we developed our framework based on a set of national health-care system goals that we identified. From these goals, we developed criteria for HIT assessment in a national context.

Goals of a National Health Care System

The goals of national health care systems vary across countries. Ultimately, however, these goals can be categorized into three themes: promoting population health, efficiency, and equity of the health care system (WHO, 2000). In this case study, we shall use these three systems goals as our foundation to develop our assessment criteria. In order to achieve these systems goals, we propose that a national health care system may identify the following specific goals:

- (1) improvement of population health measures,
- (2) health care quality improvement,
- (3) system-wide efficiency (macro efficiency),
- (4) clinical efficiency (micro or technical efficiency),
- (5) equitable access and financial burden,
- (6) system-wide cost control,
- (7) minimization of administrative and transaction costs, and
- (8) improvement in governance and system responsiveness.

These eight goals, while being normative, nevertheless contain the United States' Institute for Medicine's six aims for health care (IOM, 2001). By striving to achieve these eight goals, we may assume a national health care system can achieve the three broad systems goals discussed earlier. At the same time, we recognize that each nation's health care system goals may not be the same as our broad general goals. As such, these eight specific goals we proposed are not meant to be universal, but should be modified accordingly.

Goals and Criteria for Assessing a Health Information Technology System

In this section we develop our criteria for assessing HIT by first establishing the goals of an HIT system in a national health care system. The WHO defines the goals as follows:

The ultimate objective of a health information system is to produce information for taking action in the health sector. Performance of such a system should therefore be measured not only on the basis of the quality of data produced, but on evidence of the continued use of these data for improving health systems operations and health status. (WHO, 2005)

Using WHO's defined goals as a foundation, and the general health system's goals as guidance, we then develop goals of HIT for our study. First, we assume that the primary purpose of implementing HIT is to enhance the health care system's capacity to achieve its goals. To assess how well the implementation of HIT may help in achieving these goals, therefore, we develop the following five criteria. Each of these criteria will be closely linked to one or more of the above goals (Chaudhry et al., 2006). While our scope of HIT is broader than an electronic health record system, the goals and functions of HIT, and criteria we set up for assessment, encompass the eight core functionalities for an Electronic Health Record System developed by the Institute of Medicine (IOM, 2003). Further, our assessment of HIT will emphasize system-wide functions that link and integrate the financing agency, population, and providers.

In 2008, the Health Metrics Network under WHO developed a comprehensive assessment tool for assessing a national health information system (WHO, 2008). This tool identified numerous items within each of the five core dimensions it identified, with a comprehensive assessment method. While such measurement and assessment is a rational approach, it is very

complicated and relies heavily on a sophisticated infrastructure of data collection, assembly, and evaluation that, in practice, can be prohibitively expensive and resource intensive to assess each item according to the scoring method. Further, it assumes a sophisticated infrastructure, both in HIT and in general health care system information gathering and assembly, which is largely lacking at present for most middle-income nations and all low-income nations. Its practical use, therefore, is very limited to a few high-income nations.

Our goal is to create an approach that is more accessible, by simplifying the process and avoiding the need to establish a massive infrastructure for data collection, assembly, and analysis. Further, in the process of developing this framework, we do not assume a sophisticated state health management or HIT system, and intend for its feasibility and adaptability for middle-income nations and some low-income nations that have a basic structure of a national health system. For this purpose, based on our defined goals of HIT, we identified five criteria for assessing a national HIT system in each area. Each criterion is logically connected to achieving a national health system's overall goals. We describe these criteria below, and summarize them in [Table 1](#). Note that while in this paper we focus on Phase I qualitative assessment, these criteria we developed can be applied throughout Phases II and III. Clearly defined and measurable endpoints, as well as objectives to be achieved in each criteria, can be developed based on the country-specific context, after the Phase I assessment.

Criterion 1. How well does the HIT provide accessible and accurate public health and health care information to the population?

This criterion aims at measuring whether and how HIT in a health care system provides relevant, accurate, and timely health information that is accessible to its population. Such information will contribute to health promotion and disease and injury prevention among its population, as well as improved governance and responsiveness (Goals 1 and 8). Examples of HIT relevant to this criterion are websites set up by government health agencies or nongovernmental organizations (NGOs) that provide free access for health information, or websites that assist its population in locating and accessing health care services. For countries that lack highly accessible Internet, an alternative would be information distributed by printed materials, or even verbal communication in cases of a low literacy region. On the other hand, for countries with highly accessible wireless Internet, an example could be interactive websites designed for handheld devices such as mobile phones or WiFi devices. To assess a national HIT on these criteria,

one will need to adapt them to their information infrastructure context, and select specific endpoint measurements accordingly.

Criterion 2. How well does the HIT collect, organize, and provide population health and health care data for government and researchers to analyze population health, health needs, and processes and outcomes of health care services provided?

This criterion aims at measuring whether the HIT of a health care system is capable of collecting and organizing population health data and makes it accessible for government and researchers to evaluate the population health needs, as well as to evaluate the quality, effectiveness, and cost efficiency of the health care services being provided. This function is a foundation for promoting both system-wide and institutional-level efficiency (Goals 3 and 4), quality improvement (Goal 2), and cost control (Goal 6). Further, such a function can also provide the foundation for assessing equity of access to health care and financial burden of health care (Goal 5). Thus this criterion is critical in providing necessary information for a health-care system's continuous improvement. Examples of HIT relevant to this criterion include national health and national health care data banks, and National Health Accounts (NHA). A critical foundation for such a data system is digitized patient record and claim data, and selective population health databases such as immunization records and cancer registry. While the needs and usage of HIT by government agencies and researchers may differ and may require different levels of privacy and security policies, the focus of this criterion is on the HIT's ability to generate information that contributes to population health. A study by [Overhage, Suico, and McDonald \(2001\)](#) found that use of a county-based electronic system for reporting results led to a 29% increase in cases of shigellosis identified during an outbreak and a 2.5-day decrease in identification and public health reporting time.

Criterion 3. How well does the HIT provide accessible and timely information that helps to improve provision of cost-effective health care at an institutional level and promote system-wide efficiency?

This criterion aims at assessing whether the HIT of a health care system is capable of providing accessible relevant information for policy makers at national and local levels to make health care policies that improve system-wide efficiency (Goals 3 and 6), and for providers at the institutional level to provide cost-effective health care services (Goals 2 and 4). Examples of HIT relevant to this criterion include website that provides easily accessible

information on health technology assessment, and clinical guidelines that are built into a digitized patient record system. In a study by [Kucher et al. \(2005\)](#) using a randomized controlled trial, they found that the use of computerized surveillance and identification of high-risk patients plus alerts to physicians resulted in a 3.3% point absolute decrease (from 8.2% to 4.9%) in combined primary endpoint of deep venous thrombosis and pulmonary embolism in high-risk hospitalized patients.

Criterion 4. How well does the HIT minimize transaction and administrative costs of the health care system?

This criterion aims at measuring whether the HIT of a health care system contributes to minimizing transaction costs throughout the entire health care system, including compliance costs and administrative costs (Goals 6 and 7). Assessment of these transaction costs should not be limited to monetary costs, but also include nonmonetary costs such as patients' and providers' time. Examples of HIT relevant to this criterion include uniform digitized patient records and claim forms, and portable data storage devices such as an IC card (embedded integrated circuit) for every resident of the nation. It also includes HIT that is capable of monitoring and preventing flawed claims. For middle-income and low-income countries that are yet to develop infrastructure for digitized patient records, this criterion might be assessing whether they have a system of transferring patient records across different health care institutions when patients are being referred. One large study by Tierney and his colleagues used a randomized controlled trial to evaluate the impact of implementing information technology on reduction of transaction costs for inpatient services of an urban public hospital. They found that the intervention group generated charges that were \$887 (12.7%) lower per admission than that of the control group, which amounted to more than \$3 million in charges annually for this hospital's medical services ([Tierney, Miller, Overhage, & McDonald, 1993](#)).

Criterion 5. How well does the HIT provide channels for population participation in system governance while also protecting individual privacy?

This criterion aims at assessing whether the HIT of a health care system provides channels for its population to feed its preferences back into the system and enhance the population's participation in system governance, thus making the system more responsive (Goal 8). This system-wide population governance is concerned primarily with priority setting in public health programs and health care services, accessibility of health services, and

Table 1. Criteria for Assessing Health Information Technology in a National Health Care System.

Criterion	Health System Goals	Examples
1. <i>How well does the HIT provide accessible and accurate public health and health care information to the population.</i>	(1) Improve population health measures. (2) Improve governance and system responsiveness.	<ul style="list-style-type: none"> • Website-based comprehensive health promotion information • Website-based information that assist its population in accessing health care services
2. <i>How well does the HIT collect, organize, and provide population health and health care data for government and researchers to analyze population health, health needs, and processes and outcomes of health care services provided.</i>	(1) Health care quality improvement (2) System-wide efficiency (3) Clinical efficiency (4) Equitable access and financial burden (5) System-wide cost control	<ul style="list-style-type: none"> • National health databank • National health care databank • National Health Account
3. <i>How well does the HIT provide accessible and timely information that helps to improve provision of cost-effective health care at an institutional level and promotes system-wide efficiency.</i>	(1) Health care quality improvement (2) System-wide efficiency (3) Clinical efficiency (4) System-wide cost control	<ul style="list-style-type: none"> • Website that provides easily accessible information on health technology assessment • Clinical guidelines that are built into digitalized patient record system
4. <i>How well does the HIT minimize transaction and administrative costs of the health care system.</i>	(1) System-wide cost control (2) Minimize administrative and transaction costs	<ul style="list-style-type: none"> • Uniform digitized patient records • Uniform digitized claim forms • Online claim filing and reimbursement • Portable data storage device such as an IC card for every resident of the nation
5. <i>How well does the HIT provide channels for population participation in system governance while also protecting individual privacy.</i>	(1) Improve governance and system responsiveness	<ul style="list-style-type: none"> • An interactive website that collects and feeds population preferences into the system • Data security system

decision-making processes. At the same time, given the assembly and transaction of massive personal health data in HIT, it should also protect individual privacy (Goal 8). Examples of HIT relevant to this criterion include an interactive website that collects and feeds population preferences into the system, and data security systems.

Assessment Method

Using these criteria, we will examine HIT in Taiwan's national health care system and assess its impact on achieving the health care system's goals. Given that we will be carrying out the Phase I assessment in this study, we shall be using administrative records review, including official policies and government agencies' website information as our primary method of assessment. Further, we will examine each criterion and search whether any HIT relevant to this particular criterion is being implemented. We will then assess qualitatively whether such technology contributes to the health system's goals based on the same criterion. More specifically, our assessment will focus on the following components of HIT:

- (1) availability of HIT,
- (2) accessibility of HIT,
- (3) utilization of HIT, and
- (4) impact of HIT in achieving the criterion's goals.

Since the purpose of Phase I assessment is to establish the foundation and values of the HIT system and its assessment in Phases II and III, the approach we undertake is both normative and qualitative in nature. These same four components can be applied in Phases II and III by collecting empirical quantitative data. In this Phase I demonstration, for each component we will assign a three-level ordinal grade—high, medium, and low—to indicate how well the HIT we assessed has achieved the component of the criterion. Given that these health system goals and criteria we developed are assumed idealistic, generic, and not specific to Taiwan's health care system, we do not expect Taiwan's HIT system to fully achieve every criterion. Further, we recognize that due to limitations on availability of information, we might not be able to assess some of these components adequately and, in some cases, not at all. In addition, we intentionally left out one important component: quality of HIT. This was partly due to the limitation of available data, but also our concern for the scope of study. The inclusion of this component would require a lengthy discussion on

identifying criteria around quality of HIT, justification of these criteria, and the methods of assessing them, which would greatly expand the scope of this study. Using Taiwan as a case study, which has not reached all ideal stages of HIT according to our criteria, we believe, will make this case study more informative for researchers and policy makers across the world who are interested in implementing our framework or process. It can inform readers where and how Taiwan succeeded in achieving these goals and where it still has great room for improvement.

A BRIEF INTRODUCTION OF TAIWAN'S NHI SYSTEM

Taiwan implemented its NHI system on March 1st of 1995, providing universal coverage of health insurance. This system consolidated previous publicly financed health insurance systems, including Public Employee Health Insurance (included coverage of family members), Labor Insurance (employee-coverage only), Farmers' Health Insurance, and Fishermen's Health Insurance, into a single-payer system. This NHI system provides uniform benefits for everyone, with a mixed financing scheme. Within less than 2 years of implementation, health insurance coverage in Taiwan expanded from 55% to 99% of the population (Lu & Hsiao, 2003). Further, this universal NHI system was developed based on the nation's constitution that its government has an obligation to provide universal health care for all of its citizens (Republic of China, 1947). Such value was also stated in the WHO's Constitution (WHO, 2006):

Governments have a responsibility for the health of their peoples which can be fulfilled only by the provision of adequate health and social measures.

Taiwan's NHI is financed primarily through an earmarked payroll tax, and supplemented by general tax revenue. In 1995, this earmarked tax was originally capped at 4.25% of payroll. During the 16 years since its inception, it was raised twice: first to 4.55% in 2003, and to 5.17% at the beginning of 2011. This earmarked payroll tax is further divided among employees, employers, and government, with employees contributing 35% to 70%, and government contributing 0% to 70%, depending on which of the seven categories one belongs to. Although employers do contribute to the earmark tax, coverage and eligibility are not dependent on employment. For example, the self-employed and unemployed are covered under different financing schemes. Further, those who qualify as low-income households,

active military personnel, and veterans (but not their family) receive 100% subsidies from the government (Bureau of National Health Insurance (BNHI), 2011b, n.d.-e). This NHI system covers all citizens of Taiwan, as well as visitors who stay in Taiwan for at least 4 months. It offers very generous health care benefits that include outpatient services, inpatient services, dentistry, prescription drugs, physical therapies, Chinese medicine, and limited long-term care. This NHI system is administered by the BNHI, which is an agency under the Department of Health (DOH). The BNHI administers the NHI system with substantial decentralization by dividing the whole nation into six regions, which are administered by regional bureaus.

Most health care providers in Taiwan are private. Among the 508 hospitals in Taiwan in 2010, 82 (16.1%) of them were state owned and 426 (83.9%) were privately owned. These hospitals provided 68.61 beds per 10,000 population (DOH, 2011c). State hospitals tend to be large general hospitals; therefore, although they comprise only 16.1% of the total hospitals, they claim 33.79% of total hospital beds (BNHI, 2011a). Likewise, most clinics are private in Taiwan. In 2010, among 20,183 clinics, 461 of them were state owned versus the 19,722 that were privately owned. There were 16.77 practicing physicians per 10,000 population (DOH, 2011c). Since NHI is the only comprehensive health insurance program available in Taiwan, nearly all of these provider organizations, state owned or private, are contracted with BNHI to provide health care services. Under Taiwan's NHI, all beneficiaries have complete freedom to access any contracted providers, from private single practice clinics to the outpatient departments of teaching hospitals. Although commercial health insurance plans are available, in light of the comprehensive and generous coverage of NHI, there is no market for comprehensive private health insurance plans. Instead, these commercial plans act as supplemental health insurance that mostly cover cost sharing under the NHI, along with a few specific treatments that are not covered by NHI.

The payment system under Taiwan's NHI is a combination of global budget, diagnosis-related group (DRG) prospective payment, and relative value scale payment systems. At the end of each year, the NHI Medical Expenditure Negotiation Committee (an agency under the DOH parallel to BNHI) sets up the national global budget of NHI for the following year. Members of this Committee include representatives from the hospital sector, clinic sector, dentistry sector, Chinese medicine sector, major labor unions' national organizations, academics, and government officials. The negotiation process can take over a month to reach an agreement on two

key decisions: the rate of increase for the following year's total global budget and how this total global budget is to be divided among four provider sectors. The finalized budget is divided into four sector global budgets: hospitals, clinics, dental clinics, and hospitals and clinics of Chinese medicine. These budgets are then allocated to six Regional Bureaus. Each sector's payment is based on a relative value scale except that of hospitals, which moved to a DRG system in 2011 (BNHI, n.d.-c, n.d.-j, n.d.-l).

Since the beginning of implementing NHI, the BNHI has been very aggressive in adopting various HIT to administer this national program. These new HITs address the needs of providers, BNHI, and NHI beneficiaries, which are the subjects of our assessment. While our case study of assessment is on Taiwan's overall health system, which includes both a public health system and a national health care system, our assessment of Taiwan's HIT is to be understood with this specific NHI system we just summarized in mind.

Assessment of the HIT System in Taiwan: An Example of Applying the Framework to Assess a National HIT System

In this section, we will assess Taiwan's HIT by examining each criterion we set up in the previous section. To assess how well each criterion is being achieved, we will examine all relevant HIT that has been implemented in Taiwan.

Criterion 1. How well does the HIT provide accessible and accurate public health and health care information to the population?

To assess this criterion, we will focus on HIT that is being implemented by BNHI or DOH in Taiwan. We conduct this assessment by looking into the following categories of information that are relevant to the population's health care and health.

Access to NHI

One key issue of enrollment under Taiwan's NHI is transition in enrollment status. All residents of Taiwan are eligible for NHI benefit through different statuses, as an employee, self-employed, unemployed community member, or dependent thereof. When a person changes employment, they also have to change their employment information with the BNHI because their employers are contributing the earmark tax. In addition, when a beneficiary leaves the country for over 6 months, she can suspend her enrollment and

thus be exempt from the earmark tax. Upon returning to Taiwan, she must re-enroll into the NHI. These complicated enrollment, suspension, and re-enrollment processes require clear and accessible information for beneficiaries. The BNHI has established very accessible and user-friendly websites for beneficiaries to find this information, including all downloadable necessary forms (BNHI, 2011b). Individuals can access their entire medical care utilization information stored as an electronic record. Information is also available for beneficiaries dealing with disputes on their earmark tax. Besides serving beneficiaries, the BNHI website provides comprehensive information for employers, including an online application to enroll their new employees into NHI (BNHI, 2011b). For those who do not use or have access to the Internet, the BNHI has established information assistance throughout the hierarchy of government offices, ranging from city, county, district, to township governments that provide face-to-face consultation and assistance to all people.

Access to Health Care Providers

The BNHI website provides comprehensive information on providers, which is of importance given that beneficiaries have complete freedom in choice of provider. It includes detailed information such as office hours of all contracted providers, formularies of prescription drugs covered by NHI, hospitals that provide 24 hour emergency services (not all hospitals provide such access), the percentage of contracted beds (regular wards) in each hospital, and lists of procedures that are not covered by NHI (BNHI, 2011b, n.d.-a, n.d.-f).

Access to Quality of Care Information

The BNHI website on providers lists a limited number of health care quality indicators. They include the ratio of insurance beds to total beds in each hospital, same hospital emergency room readmission within 3 days after discharge, same-day-same-hospital emergency room readmission rate, and the ratio of more than 2 days stay in a hospital emergency department temporary bed. In addition, the website includes a searchable nationwide map that beneficiaries can use to research any hospital and its 21 indicators of quality. The same national database is also searchable for clinics and their 20 indicators of quality, and for dental clinics with 17 quality indicators. Further, the DOH website also publishes hospital accreditation results that are available to the public (DOH, 2011d).

Access to Health Promotion Information

The Hospital Administration Commission under the DOH provides a free interactive online education program called Formosa e-Medical School (DOH, n.d.-a). Under this online program, it offers full-length courses of online learning for the general population (and courses for professionals that we will introduce later). These online courses are organized into the following areas: Asthma and Chronic Pulmonary Respiratory Obstruction, Arthritis and Rheumatology, Cardiovascular Diseases and Hypertension, Common Psychiatric Conditions, Common Tumors among Females, Dementia, Diabetes, Eye Diseases, Kidney Diseases, Liver Cirrhosis and Diseases, Long-Term Care, Obesity, Shoulder Joint Arthritis and Conditions, and Stroke and Cerebral Vascular Diseases (Hospital Administration Commission, n.d.). The same website also provides very extensive online medical consultations, including pharmaceutical, nutritional, and health promotion consultations (DOH, 2011b). In addition, it also contains online self-assessments of various health status measurements (DOH, 2011b). Besides the DOH's website, the Bureau of Health Promotion (under the DOH) and the BHNI also provide extensive health promotion information on their websites (Bureau of Health Promotion, n.d.).

In assessing this first criterion, there is little doubt that Taiwan's HIT has met the availability criterion. In fact, the HIT for this criterion amounts to oversaturation with multiple government agencies providing redundant information. For example, the DOH, Bureau of Health Promotion, BNHI, and even health departments at city and county levels provide similar health promotion information (Taipei City Government Department of Health, 2011). Given that the Internet is not bounded by locality, these websites could be consolidated to provide extensive yet streamlined and consistent health information.

While HIT for this criterion is abundant, we have no basis to assess how accessible they are for residents who do not have access to the Internet. For those who do, we also do not have information to assess how much they are being utilized, or how they contribute to the health system's goals.

Criterion 2. How well does the HIT collect, organize, and provide population health and health care data for government and researchers to analyze population health, health needs, and processes and outcomes of health care services provided?

Taiwan's DOH and National Health Research Institute (NHRI) have collected the comprehensive National Health Interview Survey every 4 years since 2000 (NHRI, n.d.-b). This data bank, which contains three surveys so

far (2001, 2005 and 2009), as well as full reports, is available for researchers to analyze the state of national health (NHRI, n.d.-b). In addition, since Taiwan implemented its NHI system in 1995, BNHI has been assembling population health care data based on the complete claims submitted by all providers in the nation. This massive national health care database, the National Health Insurance Research Database (NHIRD), is organized and managed by the NHRI. Any researcher may submit a request for specific components and years of data, and NHRI will distribute the specified data set (without individual identifiers) to the researcher.

Ever since the NHIRD became available, it has greatly enriched both quantity and quality of research on health services and population health in Taiwan. It has also helped generate an enormous number of research manuscripts published both domestically in Chinese and in international journals. This published research ranges across health services research (Cheng & Chiang, 1997), health information databank technology (Chen, Yeh, Wu, Haschler, & Chen, 2011), and population health (Chen et al., 2007, Wen, Tsai, & Chung, 2008). Chen et al. (2011) documented the research accomplishments contributed by NHIRD. Between 2000 and 2009, 210 papers using NHIRD were published, 383 studies based on NHIRD were conducted, and a cumulative of 667 authors participated in these publications. The NHIRD not only enriched the knowledge base of Taiwan's health system, but also contributed to the international literature on health and health services research.

Another HIT that is helpful for both researchers and policy makers is the National Health Account (NHA). The DOH has been collecting national health expenditure (NHE) data according to NHA classification since 2000, and the latest data available are of 2009. All NHE data are posted as Excel files and downloadable from DOH's website (DOH, 2011a). These data are very helpful for both researchers and policy makers to analyze and understand the distribution of health care expenditure and financial burden, which is essential for tracking and documenting equity in health care and health systems finance (Bambas, 2005).

Judging from these accomplishments, Taiwan's HIT has high levels of achievements in availability, accessibility, and utilization of HIT for this criterion. As for impact in achieving this criterion's goals, judging from the number of research and publications, it also has achieved this component.

Criterion 3. How well does the HIT provide accessible and timely information that helps to improve provision of cost-effective health care at the institutional level and promote system-wide efficiency?

The NHRI Evidence Based Practice Guideline (NHRI, n.d.-a) provides rich and useful evidence based clinical practice information for practitioners in Taiwan. In addition, the NHRI also provides the Cochrane Library with easy online access to vast evidence-based practice literature and guidelines. This service is free to all users, with the support of John Wiley and Sons (NHRI, 2011).

The BNHI website also provides public information on providers' quality of care indicators (BNHI, n.d.-g, n.d.-h, n.d.-i, n.d.-k). This information is focused on six treatment procedures, that of diabetes, renal dialysis, knee surgery, peptic ulcer, uterine fibroids surgery, and asthma. Each disease or procedure includes multiple indicators of quality. Both providers and patients can search on this website to identify the quality of care of a specific provider, or any provider of a specific geographical location by selecting them on the hyperlinked map of Taiwan. This information not only provides helpful quality guides for patients but also places a sort of "peer pressure" on all providers because they can identify others' quality indicators while their own are also displayed publicly. Such transparency can motivate practitioners to improve their quality of care (Foy et al., 2005).

Besides BNHI, the DOH is also actively developing HIT to assist providers in improving their quality of care. The Hospital Administration Commission under the DOH provides a free interactive online education program called Formosa e-Medical School (DOH, n.d.-a). Under this program, it offers 14 full-length continuing education courses for health professionals. They include: (1) chronic liver diseases and liver cirrhosis, (2) diabetes, (3) common cancers among females, (4) ophthalmology, (5) kidney diseases, (6) hypertension and cardiovascular diseases, (7) stroke and other cerebral vascular diseases, (8) asthma and chronic obstructive pulmonary diseases, (9) common psychiatric conditions, (10) rheumatoid and arthritis, (11) long-term care, (12) obesity, (13) dementia, and (14) common conditions of shoulder joints (Hospital Administration Commission, n.d.). Many of these online courses can also help health professionals earn continuing education credits.

Another HIT for providers offered by the government is the National Health Insurance Dispute Mediation Committee's Report (National Health Insurance Dispute Mediation Committee, n.d.), which provides online information on coverage and reimbursement related disputes. Many of these disputes also cover information regarding BNHI's rejection for coverage or reimbursement of certain procedures or drugs. In discussing these disputes, the report often provides evidence-based practice literature that is helpful for providers.



Since 2002, the BNHI has implemented a global budget system, which incorporates a game-theory framework of incentives. The relative value scale is measured by a point system in which the value of each payment point is floating annually pending the total volume claimed within the same sector in the same region. That is, if the same category of providers in the same region make more claims in a given period, their base reimbursement value for the relative value scale (point) of each procedure becomes smaller, thus translating into lower reimbursement levels for that procedure. Under this reimbursement system, providers of the same category in the same region have incentives to restrain from overprovision of health care. For this incentive to work effectively, providers will need to know where they are in term of the base value of reimbursement, which is highly dependent on total volume claimed by their peers. For this purpose, the BNHI has a website that publishes both total volume claimed and the estimated base value of reimbursement point every season (BNHI, n.d.-c). This seasonal information helps providers in the same category and same region be aware of their overall claims versus total claims and estimated value of reimbursement. If the volume of claims is too high, leading to lower base reimbursement, they will either have to refrain from expanding the volume, or place pressure on their peers in the same region through their professional associations.

During the last 5 years, both DOH and BNHI stepped up its implementation of new HIT and integrated them into its comprehensive HIT system. These new HIT include Infectious Disease Surveillance (implemented in 2007), Cloud Computing for Health Databanks (implemented in 2008), and most notably, Image Exchange Center (IMC) (Chen, 2011). This IMC establishes a national center for patients' diagnostic imaging, which is administered by DOH. It makes patients' diagnostic imaging available online for contracted providers, thus reducing duplication of costly imaging services, while also saving patients from having to request and carry those diagnostic images when they are referred to different providers (DOH, n.d.-b).

In assessing this criterion, we found that Taiwan's HIT has achieved both availability and accessibility. As for utilization and impact, we do not have adequate information to assess them.

Criterion 4. How well does the HIT minimize transaction and administrative costs of the health care system?

Taiwan has four major systems of HIT related to this criterion. The first one is digitized patient records and claims, which is the foundation of the

infrastructure of Taiwan's NHI HIT system, and is closely linked to the other three, online claim submissions, smart IC card for every beneficiary, and the BNHI virtual private network (BNHI VPN). The greatest incentive for Taiwan's providers to digitize their patient records and claims was online claim submissions and reviews. By online submission, providers can receive reimbursement from BNHI within 15 days. If there is any question or problem with a particular claim, BNHI will contact providers within 5 days. The online claim submission saves substantial administrative costs on both sides. For this purpose, the BNHI established its virtual private network (VPN) in 1999, and significantly expanded it in 2005 (Li, n.d.). This VPN is accessible by all contracted providers, through which providers submit their claims online, and receive confirmations or feedbacks from BNHI's claim reviews. Further, providers can check what stage of processing their claims are in and the expected payment date, all of which is online. Among all providers that BNHI contracted, 100% of claims were submitted online through BNHI VPN (BNHI home page, BNHI, 2011b).

One important component of Taiwan's HIT system on patient record and claims is the implementation of smart integrated-circuit (IC) cards. The IC cards took 3 years to plan, starting in 1999, with implementation beginning in October, 2002. By January 2004, all beneficiaries of NHI had been issued an IC card (BNHI, 2011b). This IC card serves multiple functions. Besides serving as the beneficiary's photo identification card, it also stores four sections of information, which include:

- (1) personal basic information (such as name, ID number, birth date, and sex);
- (2) health insurance information (such as most recent utilization code number, cumulative medical care utilization, cumulative medical care costs, cumulative cost sharing, insurance tax, and preventive care);
- (3) medical information (such as major diagnoses, prescriptions, and allergies to pharmaceuticals and biological products); and
- (4) health administration information that includes vaccinations and organ donation information.

Due to strong opposition from human rights groups and other civil organizations with concern about individual privacy, the BNHI decided not to store complete patient records, diagnostic procedure results, and lab tests in the IC card at this time, despite having the capacity. All information on the IC card is encrypted, and only the BNHI issued card reader can read and retrieve information. All contracted providers are issued a card reader. In

addition, all regional offices of BNHI have card readers available for beneficiaries to read their own IC card (BNHI, n.d.-d).

These first three components are connected through the BNHI VPN and form the platform of Taiwan's NHI management information system, but also contribute to Taiwan's HIT system. They allow BNHI to carry out real-time monitoring of utilization. The lead author of this paper has had a first-hand experience of the capability of real-time monitoring. In 2006, the author was having a meeting with the manager and other top administrators of the Taipei Regional Bureau of NHI, when a staff member interrupted the meeting to report to the manager. The staff member told the manager that patient X, who had been widely reported by the media to utilize hospital outpatient departments almost daily, had just entered a hospital outpatient department. The patient's IC card had been read by that hospital's card reader and the information was immediately transmitted to the Taipei Regional Bureau in real time. They were following this patient's IC card partly under the BNHI's policy to conduct case management for anyone who had more than 20 outpatient visits per month, and partly because the media pressured the BNHI to be a better steward of public resources. This incident illustrated the capability of this HIT system to conduct case management, while also demonstrating the concern for individual privacy.

This HIT system also contributes to reduction of duplications in diagnostic procedures and laboratory tests, as well as duplications or contraindications of prescription drugs. Since Taiwan's residents have complete freedom to seek health care from any contracted providers, from private clinic to teaching hospital's outpatient department, significant duplications of diagnostic procedures and laboratory tests occurred before this HIT system was implemented. Hospital A had no information on what diagnostic procedure or tests had been performed on the same patient who visited hospital B shortly before coming to hospital A. With this HIT system, all providers can not only learn the diagnostic procedures the patient has been administered by other providers, but can also obtain the patient's diagnostic results by connecting online to the national Imaging Exchange Center set up by DOH. One research project funded by BNHI to evaluate the effectiveness of the IC card found that duplication of computerized tomography (CT) and magnetic resonance imaging (MRI) of patients within 90 days significantly reduced between 2004 and 2006, after IC cards were fully implemented (Tsai, 2007).

In assessing this criterion, we found that Taiwan's HIT has achieved availability, accessibility, and utilization by providers, as evidenced by the high percentage of online claims and digital records. As for impact, the low

administrative costs of Taiwan's NHI system, which was 1.51% of its total expenditure for 2009 (BNHI, 2010) is strong evidence of high impact in this criterion.

Criterion 5. How well does the HIT provide channels for population participation in system governance while also protecting individual privacy?

Among all our criteria, this is the area in which Taiwan's HIT has the lowest achievement. So far, most of its HIT are focused on clinical and health care administration information, and except for claim filing, tend to be a one-way exchange. The motivation for and design of Taiwan's HIT were largely focused on promoting an efficient national health care system that promotes population health. At the same time, the HIT in Taiwan has yet to develop channels for population participation in system governance. A major reason for the lack of such HIT is that the NHI has yet to develop an explicit policy and mechanism of public participation in system governance. When there is no policy of public participation in governance, we cannot expect the health care system to consider HIT for this purpose. This is a good example to illustrate that HIT exists to serve the health care system's function and purpose.

One area within this criterion that Taiwan's HIT has relatively good achievement is protection of individual privacy. In fact, the concern for privacy and technology of encryption was the primary reason it required 3 years of preparation. During these 3 years, there were many debates and public hearings on the pros and cons of using a smart IC card, as well as various technologies of encryption and the protection of personal privacy.

RESULTS OF ASSESSMENT

In this case study, we use a very simplistic measure to assess Taiwan's HIT by using a three-level scale, high-medium-low, to judge how well the HIT has achieved its goals. Based on our criteria and scale, we summarize the results of our assessment in [Table 2](#).

Out of five criteria, Taiwan's HIT achieved "High" in two of them, the 2nd and 4th criteria, while scoring one "Medium" for the 3rd criterion, and two "Low" achievement scales for the 1st and 5th criteria. With these results, our overall assessment for Taiwan's HIT is a moderate "Medium" achievement. Taiwan has made significant progress in its HIT in collecting and utilizing national health and health care data and in improving its

Table 2. Assessment of Health Information Technology in Taiwan.

Criterion	Availability	Accessibility	Utilization	Impact	Overall
1. <i>How well does the HIT provide accessible and accurate public health and health care information to the population.</i>	High	Medium	Not assessed	Not assessed	Low
2. <i>How well does the HIT collect, organize, and provide population health and health care data for government and researchers to analyze population health, health needs, and processes and outcomes of health care services provided.</i>	High	High	High	High	High
3. <i>How well does the HIT provide accessible and timely information that helps to improve provision of cost-effective health care at an institutional level and promotes system-wide efficiency.</i>	High	High	Not assessed	Not assessed	Medium
4. <i>How well does the HIT minimize transaction and administrative costs of the health care system.</i>	High	High	High	High	High
5. <i>How well does the HIT provide channels for population participation in system governance while also protecting individual privacy.</i>	Low	Low	Low	Low	Low

health care system's administrative efficiency. Where it fell short is assuring that its rich health and health care information is accessible and well utilized by its population. In the same manner, Taiwan's government can develop measures to ensure that information on improving health care quality and efficiency is being used by providers and contributing to improving their practices. As for HIT related to governance, Taiwan has yet to establish it. We do not expect this to happen before Taiwan develops a policy and mechanism for public participation in governance. To begin with, Taiwan could develop HIT that provides its population opportunities for input on policy changes, such as the current burning issues of priority setting and financing reform.

Note that in this case study we used a very crude professional judgment to assign outcome values to each criterion. Such an approach may be admissible in the initial exploratory stage of Phase I, but is not appropriate for a comprehensive assessment that can generate actionable policy implications. In the conclusion section, we shall propose a relatively more objective and systematic approach for assigning outcome values related to each criterion's assessment result.

Experiences from Other Asian Countries

Several Asian countries are also in the process of developing a HIT system. Although at the individual institutional level some of them might be employing a more advanced HIT, at the national system level, at the time of our research, few exceeded that of Taiwan in terms of progress made.

Hong Kong is one case in the region with an advanced HIT system. All of its public hospitals and clinics are connected to the same Clinical Management System (CMS) with a data warehouse consisting of 7.2 million records, which are freely interchangeable within all institutions in the public sector. Since 2004, its Electronic Health Records System (ePR) incorporated image distribution of all digitally captured radiological images and made them available online within the public sector of health care institutions that serves 90% of the hospital market in Hong Kong. During the 2003 SARS epidemics, the CMS system allowed Hong Kong to create a special module called eSARS within a very short time. This online system allowed the DOH to capture real-time situations and reporting and surveillance data, which also connected with the Police Department Geographic Information Systems. In 2005, the Hong Kong Society of Medical Informatics together with the Internet Professional Association

(iProA), the Hospital Authority, the DOH, and the Office of the Chief Information Officer established the eHealth Consortium of Hong Kong. This Consortium promotes data sharing, health information data standards, and education and capacity building in health informatics, among other initiatives (Wong, 2006).

South Korea is another Asian country with active government initiatives to implement a HIT system. Its first National Health Information Standards Committee was organized in 2004, which led the way to continuous development in different areas of information standards. In 2005, its government developed a 5-year national plan for a National Health Information Network (NHIN). The tasks of the NHIN includes implementing interoperable electronic medical records (EMRs) for public hospitals and public centers, facilitating EMR adoption among private health care organizations, developing national services through the infrastructure for health information sharing, and developing the infrastructure and governing structure for the NHIN. In the process of developing its national HIT system, Korea faced the challenges of obtaining consensus among the public and private sectors, and provided incentives for both citizens and professionals to participate in the development and utilization of its HIT system (Kim, 2006).

Singapore also has an advanced HIT system for its national health care system. Its first step was to develop hospital administrative systems supporting admissions, discharges, and billing processes. In 2004, it developed an Electronic Medical Record Exchange (EMRX) to provide an electronic platform for the sharing of medical documents. From this system, it developed its EMRs, which was designed as an organic system that allows growth and diverse subsystems to be integrated. This EMR has gradually become the umbrella system that aggregates clinically relevant electronic data from various sources, such as operating theatre management systems, e-Archival for paper-based records, web-based radiological image, and ECG repositories. Further, it also incorporates clinical workflows such as computerized physician order entry (CPOE), clinical results tracking and nursing records. At the national level, it also developed the Integrated Care Services (ICS) webportal to provide tools to connect acute hospitals, primary care providers, and the public with step-down services that include nursing homes and chronic disease facilities. One of Singapore's unique HIT services is the personal health record (PHR), which incorporates hardcopy personal health books. These not only allow individuals the ownership of their own health records, but also promote better continuity of care both at the institutional level and at home (Lim, 2006).

Japan was the first Asian country to initiate a HIT system for its national health care system. It formed its Healthcare Information Systems Advisory Committee in October of 1993, followed by the Healthcare Information System Strategy developed in 1994. In 1995, its government funded research and development for EMR, which was authorized as a formal system in 1999, and began to provide subsidies for government agencies and health care organizations to implement it in 2002. By the end of 2004, 12% of hospitals with at least 400 beds had already implemented EMR. Between 2004 and 2007, it launched major funding support and initiatives for the Interoperability of Health Information Systems Project. It developed Interoperable Healthcare and Health-Checkup Information Healthcare Public Key Infrastructure in 2006, which incorporated preventive care with curative care in the HIT system. Other landmarks include having issued e-cards for its citizen since 2003, providing incentives for promoting e-claims since 2006, and online reimbursement claims in 2011 (Kimura, 2006). One of the driving forces for Japan's HIT development has been its Cabinet IT Strategy Headquarters, which was the main designer of the government's "Information Grand Design on Healthcare, Health, Elderly Care, and Social Security" in 2007. This scheme focused on four areas of reform: (1) collection and analysis of health check-up, treatment, and receipt data; (2) installing EMRs and creating interoperability in medical institutions; (3) creating receipts for data online; and (4) establishing personal health cards (Shimada & Kondo, 2007).

Note that in this overview of other Asian countries with leading development of HIT systems, we were not able to identify published literature that uses a systematic framework to assess a national HIT system. This demonstrates the need for researchers to conduct system-wide assessments. Our current paper simply presents an example, and hopefully, also a stimulant for this area of research.

CONCLUSION AND DISCUSSION: IMPLICATIONS FOR OTHER NATIONS' HEALTH CARE SYSTEM AND FUTURE OF HIT

Limitations of This Study

HIT has become an essential tool for the modern health care system to perform its functions and achieve its goals. While most governments

recognize its importance, its implementation and assessment are still at an early stage. Further, system-wide assessments of HIT systems at the national level are very rare in the literature. In this study, we attempted to develop a simplified and systematic framework for assessing HIT in a national health care system. Using the generic goals we established for a national health care system and assuming the HIT exists to serve these goals, we developed criteria for assessing an HIT system. Note that we left out one important domain of HIT, social and environmental determinants of health, from this study in order to make this manuscript manageable. Such exclusion reduced the scope of our assessment to focus on the health care system, rather than the broader health system as defined by WHO (WHO, 2000). When interpreting the results of this study, one needs to bear this limitation in mind.

Another major limitation of this study is that we used a case study method with subjective and qualitative assessment, which we earlier defined as Phase I assessment. This was due to a lack of well-established measurement and quantitative data. This type of assessment is heavily subjective, and the results may have unidentified validity. Ideally, if data is available, one should move to Phase II and Phase III assessment, making the assessment outcome more readily applicable for policy making in priority setting.

The third limitation of this study is the example we used of Taiwan's national health care system. With its single-payer government insurance system, many of its contextual factors, such as the DOH's and BNHI's administrative authority, may not be present for countries that do not have such a system. This will limit the lessons learned from this case study to national health-care systems that bear a similar structure to that of Taiwan.

Lessons Learned

While we demonstrated the application of our framework by the case study on Taiwan's HIT, at the same time in every step of our analysis we kept broad international readers and policy makers in mind. There are four major lessons that we learned from this case study, which can be helpful for researchers and policy makers who are interested in planning, implementing, or evaluating HIT for a national health care system. Further, these lessons are consistent with the WHO Health Metrics Network's Call to Action principles for strengthening international collaboration around HIT development (WHO Health Metrics Network Call to Action, 2010).

The first lesson we learned from this case study is that it is relatively easier to establish HIT than to assess its effectiveness and impacts. One consistent

barrier to our assessment is the lack of information for assessing whether the HIT in question is being adequately utilized and achieving its goals. It is an ironic situation for us to find a lack of information for assessing HIT, especially at the national system level. As evaluation is an important part of implementation, any HIT should incorporate a function to gather information for its own assessment. Without such information, it is difficult to know how well the HIT achieves its goals.

The second lesson we learned is that a HIT system exists to serve a health care system's goals. Just like the idiom, "Necessity is the mother of invention", we may say "health care goals are the mother of health information technology". Indeed, in Taiwan's case, it did not develop HIT for population participation in the governance of its health care system, because such a policy and system is yet to be established. This means that while HIT can enhance a health care system's function and efficiency, it cannot achieve any goals that the health care system was not designed to achieve. To assess HIT appropriately, therefore, one cannot separate it from the health care system it serves. A HIT system is as good as its health care system. On the other hand, it is conceivable that advancement of information technology may present new way of organizing and delivering health care, therefore affecting the function of health care systems (Chaudhry et al., 2006).

Given the close tie between HIT and a health care system, when one is assessing a HIT system, context matters, which is the third lesson we learned from this study. At the beginning of this manuscript, we made a strong assumption by establishing a set of generic national health system goals, which helps us demonstrate how one can develop a framework for HIT system assessment. In reality, each country may share some common health care system goals while also having its own unique goals. To assess a national HIT system from the academic perspective, and in the spirit of self-determination, one will need to take the country's own health care system goals as given, and establish HIT assessment criteria based on that. This may present a challenge when one is conducting an international comparative study of HIT systems. If one wishes to use uniform criteria for international comparison, one will have to establish it based on broad consensus, or apply narrow criteria that are based on common health-care systems goals.

Finally, the last lesson we learned from this study is that a uniform health information format and compatibility of information exchange among the health system authority (such as BNHI in this case study), general population, and providers are critical for a HIT system to function well.

Such conditions, as we observed from Taiwan's case, are much easier to achieve in the presence of a national health care system (such as Taiwan's NHI system) than without (such as the United States'). Further, from this lesson, we also know that for international exchange of health information or for developing HIT across national borders, or even a global HIT system, an effective transnational governing body that has both the consensus of member states and authority is essential. In the global context, we have some successful HIT examples. The earliest one is the International Classification of Diseases (ICD), which standardized classification of health problems and made them compatible internationally (WHO, 2010b). A more recent example is the National Health Account (NHA), which standardized health systems finance terminologies, their definitions, and measurements (WHO, 2011c). These are no small achievements, which will be hard to realize without the leadership of WHO and the member states' participation. The ICD and NHA, however, are only components of HIT for a national health care system or a global system, and not a comprehensive HIT system that includes all domains of health systems. As subsystems of a comprehensive HIT, there is still very limited integration between ICD and NHA. This example tells us that there is still a long way to go for a global comprehensive HIT system that integrates all domains of health systems. When international trade of health services becomes mature, as envisioned by the General Agreement of Trade in Services under the World Trade Organization (World Trade Organization, 2011), there might be enough motivation for most countries to work together and develop consensus to establish a global comprehensive HIT system. The WHO Health Metrics Network is one of the international organizations taking the lead for this development (WHO, 2011a).

Proposed Directions for Future Research

During the current Phase I study we did not develop quantitative criteria for assessment, and no empirical data was collected for this assessment. To establish Phase II assessment, researchers and policy makers will need to select appropriate criteria and operationalize them into measurable endpoints. Further, such criteria should be country specific and, ideally, with systematic and extensive citizen participation – for the first step of determining which criteria are important is not an engineering problem, but a heavily value-based, normative issue. After those values are solicited and determined, the next stage of operationalization into measurable objectives

is an engineering problem, which should be based on systematic and scientific methods.

With measurable outcomes of assessment established, researchers and policy makers may establish specific objectives to be achieved within a given timeframe for each criterion. Moreover, researchers and policy makers will need to build into measurable criteria, the policy variables and factors that contribute to the achievement of objectives within each criterion, and set the objectives within each criterion that they expect the HIT system to achieve within given time. Actionable policies can then be established based on the outcome of the assessment. For example, based on the results of assessment, if certain objectives have not been reached, policy makers will know what actions they need to take. Further, these policy variables and factors can accommodate researchers' and policy makers' identification of mechanisms that contribute to the achievements or failure of reaching the objectives set for each criterion. The next level of assessment, Phase III, which adds costs and benefits (either in monetary terms or in utility measures such as quality-adjusted life years), can be conducted based on the results of the Phase II assessment. Moreover, as equity is one of the common and important goals of most health care systems, researchers and policy makers can also assess the distribution of the benefit of HIT system among the population.

Meanwhile, in the process of researching this paper, we found very few published literature that assess HIT at a national system-wide level, even for the Phase I assessment as we define it. It is our hope that the framework we propose here will stimulate further research and development into this area.

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REFLECTIONS ON US HEALTH CARE INFORMATION TECHNOLOGY POLICY FROM A GLOBAL PERSPECTIVE

Timothy R. Huerta and Eric W. Ford

ABSTRACT

Purpose – Health information technology (HIT) has been lauded as a foundation upon which the development of an integral solution to cost and quality problems facing many nations is predicated. Countries throughout the world have taken differing approaches in their efforts to advance that foundation through policy, financial, and cultural systems that come to support or hinder adoption. As we explore potential opportunities to learn from the experience of others, we pause to consider the environmental, regulatory, financial, and social dynamics that define the US context.

Design/methodology/approach – This chapter outlines the framework for a comparative approach through four dimensions – environmental, regulation, financial, and social – through which comparative HIT studies should be explored.

Findings – With such markedly different contexts in which their HIT is embedded, it is important to not simply look at other countries as a yardstick upon which we compare our failures and successes. Rather, we

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must look critically at these examples understanding that the dynamics at play in each context have created opportunities and obligations that have come to define each country's implementation.

Originality/value – The need for a common framework through which scholars can explore comparative HIT systems, while remaining grounded in the US context is an important aspect of effective knowledge translation in adoption.

Keywords: Framework; health information technology; comparative

An effective health information technology (HIT) system supporting the provision of care to all citizens has been lauded as an integral part of the solution to cost and quality problems facing many nations. From a financial perspective, improved business intelligence is expected to offer increased efficiency in the health care system through reductions in unnecessary testing, improved billing, and better care coordination (to name a few). In terms of quality of care, HIT is expected to support evidence-based medicine through the development of population-level databases that can be explored to identify best practices and improve care outcomes. These findings can then be fed back to the HIT applications that generated the raw data (e.g., electronic medical record (EMR) systems) in a virtuous cycle that will facilitate improved decision support and the evolution of standardized order sets. For instance, improvements in patient safety are expected from the reduced incidence of adverse drug interactions as well as an increased availability of long-term data to test the impact of pharmaceuticals. However, the realization of this vision for HIT-enabled system improvement has achieved varying levels of success dependent on the environmental, regulatory, financial, and social features of the country in which they are embedded.

As envisioned in the Health Information Technology for Economic and Clinical Health ([Health Information Technology for Economic and Clinical Health \(HITECH\) Act, 2009](#)) and Patient Protection and Affordable Care Acts ([The Patient Protection and Affordable Care \(PPACA\) Act, 2010](#)), HIT is expected to provide the platform from which the business and practice of health care service delivery in the United States will undergo a renaissance. Scope of health care has historically been defined by the relationship between one doctor and one patient with little interference from other parties. The aim of HIT-related legislation is to expand that relationship into a network of specialized caregivers for the patient while offering a population of

patients for caregivers. For instance, telemedicine and patient-led diagnostics have transformed chronic disease management with the availability of increased communication that provides more timely information. As a result, the burden on the patient is reduced and the response of the professional more timely. This has resulted in a shift in cases away from being geographically bound, to one that is open to a broader universe of care. Even without the improvements in telecommunications, the development of robust travel systems and health care tourism made the world “flat” (Friedman, 2005). However, increasing the global nature of our world has its drawbacks as well. Diseases such as avian and swine flu, tuberculosis, SARS, methicillin-resistant *Staphylococcus aureus* (MRSA) have flourished in an environment of increased connectivity – albeit not of an electronic variety.

With the significant potential to improve care quality and control costs through HIT use, it is interesting to note that adoption has been relatively slow, even in the face of government pressure (Ford, Menachemi, Peterson, & Huerta, 2009). While some note that US health care offers a level of access to diagnostic medical technology that is, at times, considered excessive, HIT has been an exception to that rule. What has accelerated the promulgation of diagnostic medical technology has not necessarily been the benefit it offers to the patient (Iglehart, 2009), but the fact that the US health care system is structured to support a higher level of medical diagnostic technology in the provision of care. As such, while revenue is directly generated from diagnostic medical technology, HIT is not similarly benefited.

Outside of the United States, there have been countries where adoption has become a priority. Nations around the globe have established policies designed to increase the use of HIT in general and EMR systems in particular in their health care systems. A report by the Commonwealth Fund found that only 28% of primary care physicians in the United States use an EMR for primary care. In contrast to the United States with an adoption rate of 28%, Finland and Sweden have proved themselves as global leaders in the adoption of EHR systems by hospitals, with 99% and 100% adoption among primary care physicians, respectively (Gray, Bowden, Johansen, & Koch, 2011). While the progress made by these nations has been impressive, many of the comparisons have an apple to oranges feature that must be considered. For instance, the country of Finland, often identified as a premiere adopter of HIT, has only 21 hospital districts as part of a health care delivery system that is far more nationalized than what is seen in the United States. The US system is characterized by its highly decentralized and heterogeneous nature and is far larger in comparison to other nations’ health

care sectors. Some US health care systems exist on scales that dwarf entire countries by comparison. Kaiser Permanente alone handles 8.7 million members' health care (Kaiser Permanente, 2012), 60% more people than the entire country of Finland. It is therefore important to consider the dynamics that help to define the US health care system vis-à-vis other nations.

Further, scholars have noted that there is a significant difference in the functionalities of EHRs across countries. In their 2009 eHealth Benchmarking report, the European Commission found a lack of discriminative power in both the definition and the factual use of the technical terms used to describe eHealth applications (Meyer, Hüsing, Didero, & Korte, 2009). Put another way – that a country has an EHR does not mean that all such systems share a common functionality. For instance, Protti (2009) noted that Norway's EHR has a high level of adoption and a low level of functionality.

ENVIRONMENT

The United States has a far greater geographic scope – ranging from the frontier counties of Texas, the rural counties of Pennsylvania, the suburban sprawl of the Inland Empire in California, and the Urban Metropolis of New York – than many of the other industrialized nations pursuing HIT ubiquity. The United States also has a more heterogeneous population, owing to its historical patterns of immigration from Europe and large African-American community. More recently, immigrants from Central and South America and Asia have entered the country in large numbers further increasing the variability in health patterns. All of this mixing of communities makes managing population health far more difficult as different illness patterns affect various subgroups in very different ways. In addition, the wide socioeconomic differences across both US regions and populations add to variability in health care status and needs. In order to address these diverse needs, better information sharing is needed to properly stratify groups for both risk assessments and program interventions.

Most efforts to create health information exchanges (HIEs) rely on state agencies to serve as the hub in the data management system. While this model may serve to connect most of an individual's care information, it also leaves clear gaps. The example frequently given is the need to access a record during an emergency. What happens if the emergency happens beyond one's home state? Alternatively, what happens when an individual family moves across state lines? While these limitations will undoubtedly eventually be

overcome, given the difficulty states have had in meeting the deadlines for establishing their HIEs, it is unlikely to be in the next decade as is often called for in the regulations.

REGULATION

Health care facilities have multiple, overlapping, and often conflicting rules and laws to follow in local, state, and federal regulators. An example of this phenomenon is evident in the health insurance exchanges mandated by the 2010 Patient Protection and Affordable Care Act (PPACA). Because states regulate which services must be covered by insurance policies and differ significantly from jurisdiction to jurisdiction, it necessitates establishing exchanges in every state. This feature has two deleterious effects. First, it requires every state to incur the fixed cost of establishing an exchange. As one of the PPACA legislation's goals was to reduce the overhead of insurance companies, the adoption of multiple systems will not support that process. A more idealized version would have been to develop fewer interstate exchanges that could be more cost effective and reduce transaction costs. Second, setting the exchanges in individual states limits the size of the population they can cover and reduces the ability of insurers to spread the risk, and in turn lower the costs, over larger groups. Such contradictory effects of regulatory efforts are a common byproduct of legislators' attempts to shape insurance markets through micromanagement and regulation.

One concern often voiced with respect to HIT is that it will facilitate or induce legislators to attempt to further micromanage the practice of medicine. The fears generally manifest themselves in two forms. One is that the EMR will become a control mechanism that dictates how care is to be provided. The second fear is that the EMR will become an instrument of the malpractice litigator. In either case, the fear among providers, physicians in particular, is that such systems will eventually lead to a form of socialized medicine via electronic fiat that will effectively make the doctor a salaried employee of the government. The financial implications for the medical profession would be significant.

FINANCIAL

The United States has a remuneration system where the expectation is now that individuals with insurance subsidize the provision of care to the

uninsured. This is made more problematic by the distortions the insurance system have created in the payment for service where the link between the cost to provide care and the expense to the patient are distorted. In both respects, the system creates what consumers perceive and providers perceive to be care cost subsidies that induce them to consume and recommend more services, respectively. The subsidies are real in that most health benefits are exempt from some or all taxation that normally accompanies sales transaction in the United States. However, the subsidy is also illusory in the sense that the same consumers then pay for it in the form of higher taxes on other income, goods, and services. The two disconnects, through insurance and tax treatments, distort the way health services are consumed in both their magnitude and quality.

The role of HIT in the financial models is most clearly enumerated in the pay-for-performance (P4P) movement. Under P4P models, data from the EMR is used to assess the quality of care given at hospitals and by physicians. Ideally, providers are to be rewarded for superlative care and penalized for substandard care. In all likelihood, the models used by government and private payers will focus on the negative aspect of the programs and implement steep penalties for poor quality. A prime example of the negative model is the denial of payment for care that results in a readmission. Such a penalty is potentially quite large and may cause some unintended consequences with respect to the way care is delivered. In the worst case, providers, hospitals in particular, may simply cease to engage in the types of services that may have a high risk of impacting their performance metrics. Such behavior would, in some respects, violate the social contract between facilities and their communities – particularly nonprofits that receive tax benefits for performing public services.

SOCIAL

The expectation of the US health care system is that the system should not be constrained by costs and attempts to do so have been met with resistance. Rationing systems are seen as antithetical to the notion of high-quality health care. Even in a nation where tens of millions of people lack health insurance, anyone can enter an emergency room and be assured that they will be treated if they have a life-threatening condition. While the social contract is far from perfect in the United States with respect to health care, it does not have explicit limitations imposed in the form of services being unavailable by regulation or through queuing requirements.

One hope for HIT is that it can deliver the best of both worlds from the social contracting perspective. If costs can be maintained, the government hopes to avoid the need to form panels such as those that exist in the United Kingdom (e.g., The National Institute for Clinical Effectiveness – NICE) to ration the types of care available. However, HIT may come to serve as an effective tool for promoting the use of effective care guidelines and the avoidance of ineffective care modalities. In this way the government gets to have its cake and eat it too in that they do not have to explicitly control care, but get to do so implicitly through an HIT solution.

Yet, even in this environment, leadership on the HIT issue has been up and coming. In 2009, the US Federal Government authorized The Health Information Technology for Economic and Clinical Health (HITECH) Act, representing an unprecedented investment of resources into the US health care system. The HITECH Act allocates \$19 billion in grants and incentives, outlines a pathway for the development of regulations pertaining to data exchange in health care, and invested significant targeted resources towards the development of the workforce necessary to support this new integrated infrastructure. The development of the modernized medical information workforce, as outlined by the HITECH act, takes a multipronged approach.

The act funds four classes of interventions to support the adoption of a robust HIT system. First, through a public consultation process, the Office of the National Coordinator developed minimum standards for IT based on a standard of “meaningful use” – requiring that hospitals and doctors do more than warehouse data. The meaningful use standard requires the exchange, interchange, and leverage of data to provide a platform for evidence-based medicine.

The second component included resources to support the transformation process. Organizations, called HITRECs, were funded using a competitive grant mechanism to provide technical support for the implementation of this new infrastructure. A third component involved the funding of educational programs at community colleges and universities for the development of a new workforce with the skills that would support both the construction, maintenance and business intelligence aspects of this new infrastructure. Finally, resources were allocated to support the development of a regional information exchange to allow for the sharing of information across organization boundaries.

At its core, these investments are based on a supposition that if you connect *the right people* with *the right information* available using *the right technology* in *the proper regulatory framework* you will positively improve population health. It is believed that the adoption of HIT including clinical

information systems, decision support systems, and networks or systems that facilitate the exchange of clinical and other health data will yield various desirable outcomes. These outcomes may include improvements in the quality of care, a reduction in medical errors, boosts in efficiencies, and improved provider and patient satisfaction. However, these innovations require changes in long-engrained practice patterns that have created significant resistance to HIT adoption in the United States.

Health care has a culture that has been at odds with the depersonalization of the patient–professional relationship. Technological integration has often been cast as interfering with the human aspect of care. Further, health care professionals have resisted the training required to adequately function in high technology environments as a skill set that is outside the scope of the provision of care. However, in many cases these same professionals are the only individuals capable of providing the information required by these same systems.

It has been noted that the cultural differences between the professional hierarchies in health care require different approaches to facilitate effective adoption. Doctors, for instance, will need to be convinced of the value that increased integration will provide to patient outcomes. Nurses will need to develop the skills and data to support the care of patients and the quality of their experience. Managers see the benefit of increased IT in terms of improved measurement of key performance indicators. Rather than focusing on the workforce that is entering the market, the dynamic at play is about transforming and empowering the workforce that exists.

Moving forward then requires that we not only look in at the successes of facilities and systems in the United States but out at other countries to understand and explore the strengths and weaknesses in their regulatory and large-scale change management approach. In many cases, the challenges faced by tightly integrated countries sharing HIT data across borders face the same challenges that organizations and states face in the United States, and at times are on similar scale.

Access to greater information will facilitate the use of more complex technological approaches to syndromic surveillance. For instance, the cyberinfrastructure program in Tobacco Control at the National Center for Supercomputing Applications (NCSA), under funding for both the National Science Foundation and the National Cancer Institute, has sought to facilitate the sharing of data, research, and ideas. Areas like tobacco control and influenza, where the evidence is clear and well organized, offer a well-developed public health priority in which to explore the efficacy of syndromic surveillance (National Cancer Institute, 2011). The CDC's

United States Influenza Sentinel Physicians Surveillance Network involves 260 physicians around the country who report the total number of patients seen and the number of those with influenza-like illness (Center for Disease Control, 2011).

Although counties outside of the United States are on different paths in their EMR adoption journey, there is still much that we can learn from the successes and failure they experience. We know that there are significant cultural challenges in the adoption of an EMR which, in no small part, are dependent upon the professional expectations among doctors, nurses, and other health care providers and professionals. We know that clear regulatory leadership is linked to the acceleration of IT adoption. At this point, business as usual will not be an option.

We must look critically at these examples understanding that the dynamics at play in each context have created opportunities and obligations that have come to define each country's implementation. While the solutions offered will eventually be uniquely American, they will not be the first attempts to do so and will be influenced by what goes on in the global context. For that reason, discourse, as presented here, plays a critical role in what may or may not work, which makes the discussion all the more critical.

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INTERNATIONAL MEDICAL GRADUATES AND HEALTH INFORMATION TECHNOLOGY USE IN THE UNITED STATES

Olena Mazurenko, Gouri Gupte and
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ABSTRACT

Purpose – Health information technology (HIT) holds promise for improving the quality of health care and reducing health care system inefficiencies. Numerous studies have examined HIT availability, specifically electronic health records (EHRs), and utilization among physicians in individual countries. However, no one has examined EHR use among physicians who train in one country and move to practice in another country. In the United States, physicians who complete medical school outside the country but practice within the United States are commonly referred to as International Medical Graduates (IMGs). IMGs have a growing presence in the United States, yet little is known about the availability and use of HIT among these physicians. The purpose of this study is to explore the availability and use of HIT among IMGs practicing in United States.

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Design/methodology/approach – *The Health Tracking Physician Survey (2008) was used to examine the relationship between availability and use of HIT and IMG status controlling for several physician and practice characteristics. Our analysis included responses from 4,720 physicians, 20.7% of whom were IMGs.*

Findings – *Using logistic regression, controlling for physician gender, specialty, years in practice, practice type, ownership status and geographical location, we found IMGs were significantly less likely to have a comprehensive EHR in their practices ($OR = 0.84$; $p = 0.005$). In addition, findings indicate that IMGs are more likely to have and use several so-called first generation HIT capabilities, such as reminders for clinicians about preventive services ($OR = 1.31$; $p = 0.001$) and other needed patient follow-up ($OR = 1.26$; $p = 0.007$).*

Originality/value – *This study draws attention to the need for further research regarding barriers to HIT adoption and use among IMGs.*

Keywords: Health information technology; International Medical Graduates; electronic health record

INTRODUCTION

In recent years, health information technologies (HIT), specifically electronic health records (EHRs), have received considerable attention throughout various international settings (AbdGhani, Bali, Naguib, & Marshall, 2008; Anderson, Frogner, Johns, & Reinhardt, 2006; Jha, Doolan, Grandt, Scott, & Bates, 2008; Schoen et al., 2006; Urowitz et al., 2008; Xu et al., 2011). Much of this enthusiasm and attention is derived from the potential benefits of using HIT to improve quality and address inefficiencies in health care systems. Estimates examining EHR use indicate that Sweden, the Netherlands, Denmark, the United Kingdom, Finland, and Austria lead other nations in overall use of EHRs (Jha et al., 2008; Ludwick & Doucette, 2009). Further, research within and across countries continues to examine the relationship between EHRs and quality of care, patient satisfaction, and cost-effectiveness, as well as physician satisfaction (Davis, Doty, Shea, & Stremikis, 2009; Hagens & Krose, 2009; Ludwick & Doucette, 2009; Schade, Sullivan, De Lusignan, & Madeley, 2006). Whereas numerous studies have looked at EHR access or utilization among

physicians in individual countries including the United Kingdom, Australia, Canada, Japan, and the United States (Archer, 2011; Archer & Cocosila, 2009; Jha et al., 2009; Robertson et al., 2010; Schade et al., 2006) and across multiple countries (Braa, Monteiro, & Sahay, 2004; Jha et al., 2008), to date no one has examined EHR use among physicians who train in one country and move to practice in another country.

In the United States, physicians who complete medical school outside the country but practice within the United States are commonly referred to as International Medical Graduates (IMGs). IMGs play a critical role in the US health system, making up 25% of practicing US physicians (American Medical Association (AMA), 2011; Education Commission for Foreign Medical Graduates (ECFMG), 2011). Further, IMGs often practice as primary care physicians in designated underserved areas (Chen et al., 2010; Cohen, 2006; Crosley & Pugno, 2011; Fink, Phillips, Fryer, & Koehn, 2003; Hart et al., 2007; Hing, Lin, & National Center for Health Statistics, 2009). Previous studies reported differences between IMGs and United States Medical Graduates (USMGs) in regard to cultural beliefs and language barriers, which can affect recruitment opportunities, personal experiences, and challenges during the residency training (Chen et al., 2011; Moore & Rhodenbaugh, 2002; Norcini, Anderson, & McKinley, 2006; Schenarts, Love, Agle, & Haisch, 2008). Currently, no known previous study has examined the use of EHRs among IMGs in the United States.

Surveys indicate that IMGs practicing in the United States typically originate from India, the Philippines, Mexico, Pakistan, China, and the Republic of Korea (ECFMG, 2011; Hart et al., 2007). Considering little is known about HIT and EHR adoption in these countries, it is important to understand the use of EHRs among IMGs in the United States. Furthermore, this information is particularly relevant within the United States, where there is a national push for HIT. In fact, the recent Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 established federal funding to incentivize clinicians to use EHRs in specific “meaningful” ways (American Recovery and Reinvestment Act of 2009, 2009; Blumenthal & Tavenner, 2010). Because of the notable role that IMGs have in the US physician workforce, it is of interest to examine their HIT adoption rates prior the passage of the HITECH Act.

The purpose of this study is to examine HIT and EHR availability and use among IMGs practicing in the United States. Using data from the Health Tracking Physician Survey (HTPS), a large, nationally representative US dataset, this chapter assesses the state of EHR use among physicians practicing in the United States who completed medical school outside the

United States. Given the growing proportion of IMGs within the physician community in the United States (Chen et al., 2010; ECFMG, 2011), this study will make a valuable contribution toward understanding the difference between IMGs and other physicians practicing in the United States.

METHODS

Study Design and Population

This study used the Center for Studying Health System Change's (CSHSC) 2008 HTPS database of American physicians. The CSHSC used the American Medical Association (AMA) Masterfile to identify the target population and used the following eligibility criteria for inclusion in the study. Included physicians were those who provide greater than 20 hours of direct patient care each week, are nonfederal employees, IMGs licensed to practice in the United States, physicians who had completed all their training, and physicians who did not request anonymity in the survey. Each eligible physician was classified as either a primary care provider (PCP) or other specialist. PCPs were defined as physicians with a primary specialty in family medicine, general practice, general internal medicine, internal medicine/pediatrics, or general pediatrics. According to the HTPS data collection methodology ([Health Tracking Physician Survey Methodology Report, 2008](#)), physicians' geographical location and specialty, was used to derive 20 sampling strata, which resulted in relatively high precision of national estimates. The response rate among eligible participants was 61.9%, yielding a sample of 4,720 physicians.

Variables

Dependent Variables

This analysis used a set of dependent variables that assessed the availability and personal use of several HIT capabilities in physician's practices. Specifically, the survey asked a total of seventeen questions about the adoption of EHRs and various HIT applications, which included ordering laboratory and diagnostic tests, exchanging clinical data with other physicians, hospitals or laboratories, and electronically transmitting prescriptions to pharmacies. EHR availability was measured by the

following survey question: “An electronic medical record (EMR) is a computer-based medical record. Does your main practice use electronic medical records?” Because we are interested in the relationship between IMG status and availability of EHR, we categorized all responses indicating that EHR implementation has at least begun (e.g., part electronic) and full EHR availability into a single category. Thus, the binary variable measured the presence of an EHR system, even if it was in the process of being implemented. The complete list of HIT capabilities investigated is available in the results tables.

The variables that assessed the availability of HIT capabilities included the following response categories: IT not available, IT available, not ascertained. The variables that assessed personal use included response categories: routinely, occasionally, not at all, not ascertained. Because this study focused on the actual use of HIT capabilities in a physician’s practice, these response categories were used to create a binary variable for “routine use” or “nonroutine use”. Following our transformation, the “routine use” category contains answers that were originally coded as “routinely,” all other categories are recoded as “nonroutine use”. The “not ascertained” response category was used by approximately 1% of respondents and was excluded from the final analysis.

Independent Variables

Our primary independent variable of interest is a binary variable for location of medical training. Physicians trained in the U. S., Canada, and Puerto Rico were grouped as “USMG” and the physicians trained in any other country were coded as “IMG”. The United States, Canada, and Puerto Rico were grouped together because medical schools in these countries are all accredited by the Association of American Medical Colleges, ensuring consistency in the training requirements of these institutions.

Control Variables

In line with the previous literature (Chen et al., 2010; Crosley & Pugno, 2011; Menachemi & Brooks, 2006), the following control variables were included in the analysis: physician characteristics (gender, years practicing medicine, specialty, race, board certification), and practice characteristics (practice type, ownership status, and geographical location). Years practicing medicine was coded as a continuous variable. Specialty was coded as a PCP (including obstetrician/gynecologists) and others. Physician race was coded as binary variable dividing the sample into whites and

others. Practice type was coded as categorical variable including solo or two physicians, groups of three physicians and a category for all other categories, such as HMO, medical school, or hospital-based practice type. Ownership status was specified as a binary variable indicating full ownership in the practice versus other categories, such as part owner, employee or independent contractor. The rationale for dichotomizing the ownership status variable is based on our assumption about inherent differences in physicians' who own their practices and others in their decisions regarding HIT adoption and use. Finally, geographical location was coded as a binary variable indicating rural or urban location.

DATA ANALYSIS

As the first step, descriptive statistics were conducted to examine the variable distributions and detect potential data anomalies. Following this, univariate relationships between dependent variables and main independent variable were examined using Chi-square analysis. Finally, using logistic regression analyses we examined the relationships between the availability and the use of each HIT capability, including EHR availability and IMG status while controlling for gender, years in practice, specialty, race, board certification, practice type, ownership status, and geographical location. All analyses were conducted in STATA Version 11.0. Significance was considered at the $p = 0.1$, $p = 0.05$ and $p = 0.01$ levels.

RESULTS

Descriptive characteristics of the sample of 4,720 physicians broken out by IMGs and USMGs are presented in [Table 1](#). IMGs differed from their counterparts with higher proportions of primary care physicians (49.4% versus 40%, $p = 0.001$), more likely to be working in solo practices (46.6% versus 29.6%, $p = 0.001$) and more likely to be a full owner of the practice (41% versus 27.8%, $p = 0.001$).

The results of the descriptive analysis did not detect any abnormal distributions of the selected variables, therefore no actions (e.g. transformations) were taken to normalize the distribution. The following section presents significant relationships between availability and use of HIT capabilities, including EHRs. The results of the entire models are presented in the [Tables 2, 3, 4, and 5](#). In univariate analysis, availability of several HIT capabilities

Table 1. Descriptive Characteristics of Study Sample ($N = 4,720$).

Physician Characteristics	IMG ($N=980$)	USMG ($N=3740$)	<i>p</i> -Value
	Frequency (%)	Frequency (%)	
<i>Gender</i>			0.35
Male	709 (72.3%)	3,470 (73.5%)	
Female	271 (27.7%)	1,250 (26.5%)	
<i>Mean years in practice (SD)</i>	17.8 (10.9)	18.2 (10.5)	0.38
<i>Specialty</i>			0.001
PCP	484 (49.4%)	1,888 (40%)	
Not PCP	496 (50.6%)	2,832 (60%)	
<i>Race/ethnicity</i>			0.001
White	359 (37.8%)	3,093 (84.5%)	
Non-white	590 (62.4%)	566 (15.5%)	
<i>Board certified</i>	801 (81.7%)	3,427 (91.6%)	0.001
<i>Practice type</i>			0.001
Solo/2 physicians	457 (46.6%)	1,109 (29.6%)	
Group ≥ 3 physicians	264 (27%)	1,595 (42.6%)	
Other	259 (26.4%)	1,036 (27.8%)	
<i>Ownership in practice</i>			0.001
Full owner	402 (41%)	1,040 (27.8%)	
Other	578 (59%)	2,700 (72.2%)	
<i>Geographic location</i>			0.05
Urban	894 (91.2%)	3,332 (89.1%)	
Rural	86 (8.8%)	408 (10.1%)	

Notes: IMG is International Medical Graduate, USMG is United States Medical Graduate, and PCP is primary care provider.

Table 2. Univariate Relationship between IMG and HIT Availability
($N = 4,720$).

Availability of HIT Capabilities (Yes)	IMG	USMG	<i>p</i> -Value
Treatment alternatives or recommended guidelines.	775 (80%)	3,136 (84.6%)	0.001
Up-to-date decision support for diagnostic and treatment recommendations based on data about your patients and practice guidelines.	683 (71.4)	2,510 (68.1%)	0.05
Reminders for clinicians about preventive services.	398 (41.8%)	2,392 (64.9%)	<0.001
Reminders for clinicians about other needed patient follow-up.	397 (41.8%)	1,288 (35.1%)	<0.001
Reminders to patients about preventive services.	373 (39.2%)	1,156 (31.4%)	<0.001
Communication about clinical issues with patients by e-mail.	246 (25.9%)	1,281 (34.9%)	<0.001
Access patient notes, medication lists, or problem lists.	542 (56.5%)	2,216 (59.9%)	0.05
Order laboratory, radiology, or other diagnostic tests.	550 (57.3%)	2,089 (56.5%)	0.655
View results of laboratory, radiology, and other diagnostic tests.	718 (74.6%)	2,934 (79.3%)	0.002
Exchange clinical data and images with other physicians.	412 (42.8%)	1,827 (49.4%)	<0.001
Exchange clinical data and images with hospitals and laboratories.	416 (43.3%)	1,782 (48.4%)	0.005
Access information on patient's preferred language.	225 (23.6%)	820 (22.4%)	0.419
Obtain information on potential patient drug interactions with other drugs, allergies, and/or patient conditions.	658 (68.3%)	2,686 (72.7%)	0.006
Obtain information on formularies.	526 (54.6%)	1,902 (51.6%)	0.093
Write prescriptions.	398 (41.4%)	1,634 (44.2%)	0.114
Transmit prescriptions to the pharmacy.	340 (35.4%)	1,363 (36.9%)	0.387
EHR adoption.	433 (44.3%)	1,959 (52.6%)	<0.001

Notes: HIT is health information technology, IMG is International Medical Graduate, USMG is United States Medical Graduate, and EHR is electronic health record.

Table 3. Univariate Relationship between IMG and Personal Use of HIT Capabilities ($N = 4,720$).

Use of HIT Capabilities (Yes)	IMG	USMG	<i>p</i> -Value
Treatment alternatives or recommended guidelines.	394 (40.2%)	1,383 (37%)	0.064
Up-to-date decision support for diagnostic and treatment recommendations based on data about your patients and practice guidelines.	321 (32.7%)	1,027 (27.5%)	0.001
Reminders for clinicians about preventive services.	173 (17.6%)	493 (13.2%)	<0.001
Reminders for clinicians about other needed patient follow-up.	209 (21.3%)	625 (16.7%)	0.001
Reminders to patients about preventive services.	184 (18.8%)	535 (14.3%)	0.001
Communication about clinical issues with patients by e-mail.	44 (4.5%)	239 (6.4%)	0.021
Access patient notes, medication lists, or problem lists.	422 (43%)	1,912 (51%)	<0.001
Order laboratory, radiology, or other diagnostic tests.	423 (43.2%)	1,680 (45%)	0.320
View results of laboratory, radiology, and other diagnostic tests.	570 (58%)	2,388 (63.8%)	0.001
Exchange clinical data and images with other physicians.	206 (21%)	1,011 (27%)	<0.001
Exchange clinical data and images with hospitals and laboratories.	201 (20.5%)	1,029 (27.5%)	<0.001
Access information on patient's preferred language.	73 (7.5%)	255 (6.8%)	0.481
Obtain information on potential patient drug interactions with other drugs, allergies, and/or patient conditions.	393 (40.1%)	1,581 (42.3%)	0.221
Obtain information on formularies.	246 (25.1%)	711 (19%)	<0.001
Write prescriptions.	279 (28.5%)	1,284 (34.3%)	0.001
Transmit prescriptions to the pharmacy.	340 (35.4%)	1,363 (36.9%)	0.003

Notes: HIT is health information technology, IMG is International Medical Graduate, and USMG is United States Medical Graduate.

Table 4. Availability of HIT and IMG Status: Adjusted Odd Ratios ($N=4,720$).

Physician Characteristics HIT Capability	IMG vs. USMG	Male vs. Female	Years in Practice	PCP vs. "Other"	Whites vs. "Other"	Board Certified vs. "Not"	Practice Type		Full Owner vs. "Other"	Urban vs. Rural
							Group ≥ 3 Physicians vs. "Other"			
							Solo/2 vs. "Other"	Physicians vs. "Other"		
HIT1	0.88	0.85	0.97***	1.21**	1.29**	1.42***	0.49***	0.53***	0.82*	0.89
HIT2	1.14	1.15*	0.97***	1.27**	0.81**	1.41***	0.54***	0.58***	0.85	0.81*
HIT3	1.31***	1.11	0.99	1.63***	0.81***	1.46***	0.54***	0.72***	0.92	0.99
HIT4	1.26***	1.22***	0.99	1.27***	0.75***	1.32***	0.66***	0.88***	0.96	0.81*
HIT5	1.31***	1.07	1.03	1.42***	0.82**	1.26**	0.84	0.95	0.96	0.97
HIT6	0.69***	0.98	0.99***	0.96	1.12	1.29**	0.55***	0.59***	0.99	1.27*
HIT7	0.98	1.32***	0.97***	0.89*	0.96	1.14	0.21**	0.42***	0.93	1.21*
HIT8	1.06	1.14*	0.99***	1.29***	0.85*	0.88	0.32***	0.55***	0.81*	1.17
HIT9	0.94	1.19*	0.97***	1.31***	1.08	1.26**	0.30***	0.60***	0.69***	1.11
HIT10	0.90	1.21***	0.99	0.93	1.08	1.02	0.25***	0.56***	0.93	1.10
HIT11	0.91	1.26***	0.99	1.09	1.04	1.01	0.52***	0.94	0.81	0.97
HIT12	1.03	0.92	0.98*	1.11	0.87	0.93	0.29***	0.42***	0.99	1.17
HIT13	0.92	0.91	0.98*	1.19***	1.16*	1.13	0.37***	0.53***	0.96	1.15
HIT14	1.14*	1.09	0.99	1.17***	0.93*	1.04	0.39***	0.45***	0.90	1.03
HIT15	0.97	1.11	0.98***	1.38***	1.04	0.93	0.40***	0.73***	1.01	1.29
HIT16	0.98	0.96	0.99	1.72***	0.97	1.10	0.70***	1.02	0.89	1.14
EHR	0.84*	1.18*	0.97***	0.93	1.02	1.15	0.18***	0.44***	0.81*	1.27*

HIT1 – Treatment alternatives or recommended guidelines.

HIT2 – Up-to-date decision support for diagnostic and treatment recommendations based on data about your patients and practice guidelines.

HIT3 – Reminders for clinicians about preventive services.

HIT4 – Reminders for clinicians about other needed patient follow-up.
HIT5 – Reminders to patients about preventive services.
HIT6 – Communication about clinical issues with patients by e-mail.
HIT7 – Access patient notes, medication lists, or problem lists.
HIT8 – Order laboratory, radiology, or other diagnostic tests.
HIT9 – View results of laboratory, radiology, and other diagnostic tests.
HIT10 – Exchange clinical data and images with other physicians.
HIT11 – Exchange clinical data and images with hospitals and laboratories.
HIT12 – Access information on patient’s preferred language.
HIT13 – Obtain information on potential patient drug interactions with other drugs, allergies, and/or patient conditions.
HIT14 – Obtain information on formularies.
HIT15 – Write prescriptions.
HIT16 – Transmit prescriptions to the pharmacy.
EHR – Electronic health record.
IMG – International Medical Graduate.
USMG – US Medical Graduate.
PCP – Primary care provider.
HIT – Health information technology.
** $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.*

Table 5. Personal Use of HIT and IMG Status: Adjusted Odd Ratios (N = 4,720).

Physician Characteristics HIT Capability	IMG vs. USMG	Male vs. Female	Years in Practice	PCP vs. "Other"	Whites vs. "Other"	Board Certified vs. "Not"	Practice Type		Full Owner vs. "Other"	Urban vs. Rural	
							Solo/2 Physicians vs. "Other"				Group ≥ 3 Physicians vs. "Other"
							Physicians vs. "Other"				
HIT1	1.16*	0.76***	0.97***	1.18***	0.91	1.5***	0.51***	0.57***	0.88	0.91	
HIT2	1.29***	0.91	0.96***	1.21***	0.81**	1.34**	0.45***	0.62***	0.93	0.98	
HIT3	1.4***	0.91	0.99*	2.68	0.73***	1.88***	0.61***	0.86	0.87	1.07	
HIT4	1.28**	1.21	0.99	1.46***	0.74***	1.37	0.77	1.01	0.92	0.78*	
HIT5	1.33***	0.96	0.99	1.73***	0.83*	1.59***	0.76*	1.11	1.21	0.93	
HIT6	0.74	0.98	0.97***	1.51***	1.21	1.15	0.27***	0.37***	1.2	2.45***	
HIT7	0.82**	1.22***	0.97***	0.94	0.99	1.17	0.22***	0.48***	0.84*	1.19	
HIT8	0.99	1.21***	0.98***	1.29***	0.85*	1.01	0.29***	0.59***	0.8	1.13	
HIT9	0.97	1.31***	0.97***	1.12*	1.10	1.32*	0.24***	0.57***	0.79**	1.10	
HIT10	0.85	1.05	0.99	0.94	1.05	1.28*	0.21***	0.56***	0.88	0.84	
HIT11	0.76***	1.23***	0.98***	1.13*	1.0	1.14	0.47***	1.01	0.88	0.85	
HIT12	1.08	0.89	0.98***	1.21	0.77*	1.01	0.23***	0.39***	0.67	0.95	
HIT13	1.04	0.92	0.97***	1.56***	1.09	1.01	0.41***	0.69***	0.89	1.01	
HIT14	1.45***	0.97	0.99	1.35***	0.84*	1.04	0.41***	0.53***	0.79*	1.10	
HIT15	0.87	1.12	0.97***	1.52***	1.11	0.98	0.38***	0.79***	1.1	1.24	
HIT16	0.83*	0.91	0.98**	2.08	0.98	1.14	0.57***	1.01	0.90	1.2	

HIT1 – Treatment alternatives or recommended guidelines.

HIT2 – Up-to-date decision support for diagnostic and treatment recommendations based on data about your patients and practice guidelines.

HIT3 – Reminders for clinicians about preventive services.

HIT4 – Reminders for clinicians about other needed patient follow-up.
HIT5 – Reminders to patients about preventive services.
HIT6 – Communication about clinical issues with patients by e-mail.
HIT7 – Access patient notes, medication lists, or problem lists.
HIT 8 – Order laboratory, radiology, or other diagnostic tests.
HIT 9 – View results of laboratory, radiology, and other diagnostic tests.
HIT 10 – Exchange clinical data and images with other physicians.
HIT 11 – Exchange clinical data and images with hospitals and laboratories.
HIT 12 – Access information on patient’s preferred language.
HIT 13 – Obtain information on potential patient drug interactions with other drugs, allergies, and/or patient conditions.
HIT 14 – Obtain information on formularies.
HIT 15 – Write prescriptions.
HIT 16 – Transmit prescriptions to the pharmacy.
IMG – International Medical Graduate.
USMG – US Medical Graduate.
PCP – Primary Care provider.
HIT – Health information technology.
** $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.*

was associated with IMG status (see Table 2). IMG physicians were more likely to have the following HIT capabilities: *up-to-date decision support for diagnostic and treatment recommendations based on data about patients and practice guidelines* (71.4% versus 68.1%, $p=0.05$); *reminders for clinicians about other needed patient follow-up* (41.8% versus 35.1%, $p<0.001$); *reminders to patients about preventive services* (39.2% versus 31.4%, $p<0.001$) or *HIT to obtain information on formularies* (54.6% versus 51.6%, $p=0.093$). On the other hand, IMGs were less likely to have HIT for *treatment alternatives or recommended guidelines* (80% versus 84.6%, $p=0.001$); *reminders for clinicians about preventive services* (41.8% versus 64.9%, $p<0.001$); *communication about clinical issues with patients by e-mail* (25.9% versus 34.9%, $p<0.001$); *access patient notes, medication lists, or problem lists* (56.5% versus 59.9%, $p=0.05$); *view results of laboratory, radiology, or other diagnostic tests* (57.3% versus 56.5%, $p=0.002$); *exchange clinical data and images with other physicians* (42.8% versus 49.4%, $p\leq 0.001$) *hospitals and laboratories* (43.3% versus 48.4%, $p=0.005$); *obtain information on potential patient drug interactions with other drugs, allergies, and/or patient conditions* (68.3% versus 72.7%, $p=0.006$). Moreover, IMG were less likely to have adopted EHRs (44.3% versus 52.6%, $p<0.001$).

Whereas Table 2 presents differences among IMGs with respect to availability, Table 3 presents data on personal use of HIT capabilities. IMGs were more likely to report routine use of the following HIT capabilities: *treatment alternative or recommended guidelines* (40.2% versus 37%, $p=0.0064$); *up-to-date decision support for diagnostic and treatment recommendations based on data about your patients and practice guidelines* (32.7% versus 27.5%, $p=0.001$); *reminders for clinicians about preventive services* (17.6% versus 13.2%, $p<0.001$) and *other needed patient follow-up* (21.3% versus 16.7%, $p=0.001$); *reminders to patients about preventive services* (18.8% versus 14.3%, $p=0.001$); or *obtain information on formularies* (25.1% versus 19%, $p\leq 0.001$). However, IMGs were less likely to report routine use of the HIT for *communication about clinical issues with patients by e-mail* (4.5% versus 6.4%, $p=0.02$); *access patient notes, medication lists, or problem lists* (43% versus 51%, $p<0.001$); *view results of laboratory, radiology, other diagnostic tests* (58% versus 63.8%, $p=0.001$); *exchange clinical data and images with other physicians* (21% versus 27%; $p<0.001$), and *hospitals and laboratories* (20.5% versus 27.5%; $p<0.001$), or *write prescriptions* (28.5% versus 34.3%, $p=0.001$) and *transmit prescriptions to the pharmacy* (35.4% versus 36.9%, $p=0.003$).

Results of multivariable regression analyses indicated that the availability of several HIT capabilities was associated with IMG status (see Table 4). Compared to USMGs, IMGs were significantly more likely to have certain HIT capabilities largely considered to be “basic” capabilities (Hing, Burt, & Woodwell, 2007; Menachemi, Ford, Beitsch, & Brooks, 2007) including: *reminders for clinicians about preventive services* (OR = 1.31, $p = 0.001$) and *reminders for clinicians about other needed patient follow-up* (OR = 1.26, $p = 0.007$), *reminders to patients about preventive services* (OR = 1.31, $p = 0.002$) and *HIT to obtain information on formularies* (OR = 1.14, $p = 0.1$). On the other hand, IMGs were significantly less likely to report *EHR adoption* (OR = 0.84, $p = 0.055$) and have *HIT that is used for communication about clinical issues with patients by e-mail* (OR = 0.69, $p < 0.001$).

Multivariate regression analysis focused on the personal use of HIT capabilities also revealed several differences between IMGs and USMGs (see Table 5). Controlling for physician and practice characteristics, IMGs were more likely to personally use the following HIT capabilities: *treatment alternatives or recommended guidelines* (OR = 1.16, $p = 0.079$), *up-to-date decision support for diagnostic and treatment recommendations based on data about patients and practice guidelines* (OR = 1.29, $p = 0.005$), *reminders for clinicians about preventive services* (OR = 1.4, $p = 0.005$) and *reminders for clinicians about other needed patient follow-up* (OR = 1.28, $p = 0.001$), *reminders to patients about preventive services* (OR = 1.33, $p = 0.011$), *obtain information on formularies* (OR = 1.45, $p < 0.001$). However, IMGs were less likely to personally use the following HIT capabilities: *access patient notes, medication lists, or problem lists* (OR = 0.82, $p = 0.027$), *exchange clinical data and images with hospitals and laboratories* (OR = 0.76, $p = 0.006$), and *transmit prescriptions to the pharmacy* (OR = 0.83, $p = 0.085$).

DISCUSSION

Several countries are moving toward HIT and EHR adoption due to the potential to improve health care delivery, increase health care accessibility, and reduce costs (Archer & Cocosila, 2009; Jha et al., 2008; Schoen et al., 2006). However, there is wide variation in adoption rates among providers in various countries (Ludwick & Doucette, 2009), and for most developing countries little evidence exists about HIT use. Therefore, with the United States moving toward the meaningful use of HIT (Blumenthal & Tavenner, 2010), it is important to know more about the availability and use of HIT

among IMGs who have completed their basic medical training in developing countries (ECFMG, 2011). In addition, this chapter also contributes to the lack of published research on IMGs and HIT especially considering that IMGs make up 25% of the physician workforce in the United States (AMA, 2011; ECFMG, 2011) and most often work in underserved areas and primary health care settings (Fink et al., 2003; Hagopian, Thompson, Kaltenbach, & Hart, 2003; Hart et al., 2007; Hing et al., 2009).

The main findings of this study indicate that IMGs are using certain HIT; however, they are significantly less likely than USMGs to have or use a comprehensive EHR in their practices. The capabilities that are used by IMGs are those often thought of as first generation HIT capabilities (Menachemi, Ettel, Brooks, & Simpson, 2006; Menachemi et al., 2007). These capabilities, for example, reminders for clinicians about patients needed follow-up and other preventive services, are less robust than the types of HIT that are required in order to qualify for meaningful use incentives (Hogan & Kissam, 2010). These differences in use of HIT capabilities may be attributable to variations in resources available to IMGs. IMGs often practice in primary care shortage locations, public hospitals, community health centers, and public health clinics (Baer, Ricketts, Konrad, & Mick, 1998; Fink et al., 2003; Hagopian et al., 2003; Hing et al., 2009), locations that are less likely to have adopted EHRs (Singh, Lichter, Danzo, Taylor, & Rosenthal, 2011). Although this study controlled for physician specialty, practice type, ownership status, and geographic location, it was not possible to control for the types of settings in which IMGs practice using the available data.

Another potential explanation for the difference between IMGs and USMGs in EHR adoption may be related to completing medical school in international settings. Given that the majority of IMGs in the United States receive their training in India, the Philippines, Mexico, Pakistan, China, and the Republic of Korea (Davis et al., 2009; ECFMG, 2011; Hart et al., 2007), all countries for which HIT availability and use are unknown and likely less commonly used than the United States, IMGs may lack expertise in this area. This lack of experience with HIT in early medical training may have an impact on IMG placement for residencies and subsequently whether they learn about HIT during graduate medical training. In addition, due to visa requirements (e.g., J-1 visa) during residency training, IMGs may be placed in underserved locations and training programs that are less likely to have integrated HIT or EHRs in their delivery system. More research is necessary to examine these issues and to explore the barriers for HIT adoption and use among IMGs.

Our study has both strengths and limitations worth mentioning. To our knowledge, this is the first study to examine the availability and use of HIT and EHRs among physicians practicing outside the country where they received their medical degrees. While this is the first such study of this population of physicians it is not generalizable outside the United States. In addition, although this study is based on a representative dataset, the information about HIT availability and use is based on physicians' subjective self-reported data. Thus, our results may suffer from "desirability" bias, for example, physicians might report higher levels of HIT availability and use than they actually have. Although it is worth mentioning that when compared to recent studies examining HIT adoption rates among primary care physicians the rates of EHR use among respondents in the survey data were in line with predictions obtained from the meta-analysis of 13 previous studies of HIT adoption rates (Ford, Menachemi, Peterson, & Huerta, 2009). In addition, this survey was not originally designed to collect information about HIT use and availability; therefore the way the questions are phrased might have been interpreted differently by some of the respondents. Furthermore, due to the cross-sectional nature of this study, the identified relationships should be interpreted as associations only. It is worth mentioning that our results might be influenced by several unobserved variables, like physicians' cultural values and opinions about appropriate ways to deliver care that we were not included in the analysis. We believe that future studies should incorporate this information and identify the magnitude of the change in the HIT adoption rates caused by these previously unmeasured variables. Also of note, data used for this study were collected prior to the passage of "meaningful use" legislation. Future longitudinal studies can examine changes in HIT adoption and use following implementation of the meaningful use incentives.

The findings of this study highlight the need for US policy makers to consider policies that can provide additional HIT training for IMGs, especially those coming from countries where HIT availability and use is unknown. One example of this would be to incentivize residency programs to provide HIT training specifically for IMGs. Although this study considered only IMGs in the United States, findings may be useful for other countries that provide medical residencies for foreign medical graduates as these physicians may also have lower rates of HIT and EHR adoption. In addition, more information and studies of foreign medical graduates from specific countries such as India, China, and Korea would provide improved information about their HIT use that could inform the development of appropriate training programs.

To conclude, IMGs represent a significant proportion of the physician workforce, therefore special attention should be given to their HIT and EHR adoption rates. In addition, because IMGs are over-represented in underserved areas, which often experience lower adoption of EHR in general, any efforts to improve the use and adoption of HIT among these physicians will be beneficial toward the HITECH goal of improving access to HIT. Future research should examine the barriers preventing IMGs from using HIT and EHRs and any additional resources necessary to improve their utilization.

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SECTION 3
SPECIFIC TYPES OF HIT AND
THEIR RELEVANCE TO
INTERNATIONAL SETTINGS

TELEMEDICINE IN AN INTERNATIONAL CONTEXT: DEFINITION, USE, AND FUTURE

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Karen A. Wager

ABSTRACT

Purpose – Use of telemedicine is increasingly prevalent in order to provide better access to expert care, and we examine telemedicine use internationally.

Design/methodology – Using Donabedian’s structure, process outcome framework, we conduct an analysis of published studies in the United States, Europe, and Asia to examine the uses, conditions treated, barriers, and future of telemedicine.

Findings – We identify several similarities and challenges to telemedicine use in each region. We find use of videoconferencing between providers or providers and patients for the treatment of acute and chronic conditions. Studies in the United States are more likely to identify applications for the use of chronic conditions, whereas studies in Europe or Asia are more likely to use them for acute access to expertise. Each region reported

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comparable challenges in reimbursement, liability, technology, and provider licensing.

Research limitations – We compare available research articles from three diverse regions, and many of the articles were merely descriptive in nature. Furthermore, the number of articles per region varied.

Practical implications – Barriers to telemedicine use include a lack of reimbursement, language commonality, technological availability, physician licensure or credentialing, trained support staff and patient privacy, and security assurances. Practitioners and policy makers should work to address these barriers.

Originality/value – Through this work, a summary of the research to date describes telemedicine use in the United States, Asia, and Europe. Identification of use and barriers may provide impetus for improving access to care by finding ways to increase telemedicine use through standardization.

Keywords: International telemedicine; barriers; diffusion of innovation

INTRODUCTION

Telemedicine is a promising health information technology (HIT) tool that can connect providers to patients in geographically disparate locations increasing access to specialty and expert care. Telemedicine can allow for the evaluation, diagnosis, treatment, monitoring, triage, consultation, and follow-up of patients without travel (Froehlich, Seitaboth, Chanpheaktra, & Pugatch, 2009; Galvez & Rehman, 2011). In the United States, approximately 200 telemedicine networks connecting more than 3,500 institutions exist, and many others exist in Europe and Asia (Eron, 2010).

The purpose of this chapter is to examine and report on telemedicine use internationally. Specifically, we are interested in the definition, settings, conditions treated, similarities/differences, and future of telemedicine in Europe, Asia, and the United States. Although there have been previous studies that have examined each of these regions independently, we contribute to the body of knowledge by providing a comparison of the three regions in the updated literature. We selected these regions because of

their size, geographical diversity, and the fact that they are all made up of developed nations. We also found evidence that each region has used telemedicine for at least 15–20 years, and given the rapidly changing nature of technology/telemedicine, we believe such an analysis is warranted and valuable. Our research question is: What are the similarities and differences in telemedicine use in Asia, Europe, and the United States? Given the potential of telemedicine use in each of these regions as well as internationally, this analysis will provide information about practices in each region and an overall assessment of how prepared the regions appear to be for international collaboration/use of telemedicine and to share best practices to promote telemedicine use.

Definition and Purpose of Telemedicine

There are literally over a hundred different definitions of telemedicine that have been used by authors internationally in peer-reviewed journals since the early 1970s. [Sood and colleagues \(2007\)](#) analyzed the various definitions and found common elements such as the provision of health care services using different types of technology to patients at a distance or when the provider and patient are separated. As this chapter examines the adoption and use of telemedicine from an international perspective, we chose the World Health Organization's definition of telemedicine:

Telemedicine is the delivery of healthcare services, where distance is a critical factor, by all healthcare professionals using information and communication for the exchange of valid information for diagnosis, treatment, and prevention of disease and injuries, research, and evaluation, and for the continuing education of healthcare providers, all in the interests of advancing the health of individuals and their communities.

(Report of the International Consultation, 1997).

Earlier definitions often included specific types of technology and modes of delivery. During the past decade, however, telemedicine has become a much more open and evolving science, as it incorporates new and emerging technologies and responds and adapts to the health care needs of communities ([World Health Organization \[WHO\], 2010](#)), and, therefore, identifying the specific technology in the definition is less common.

Another term that is often found in the telemedicine literature is "telehealth." For our purposes, we use the terms interchangeably. Nonetheless, some authors refer to telehealth as services that are provided by nonphysicians in settings outside of the traditional hospital or ambulatory care setting. These might include nurses, pharmacists, physical therapists,

and other types of health professionals who may care for patients in the home or in residential, community-based settings.

Telemedicine has four core elements:

- Its purpose is to provide clinical support.
- It is intended to overcome geographic barriers, connecting users who are not in the same physical location.
- It involves the use of various types of information and communication technology.
- Its goal is to improve health outcomes (WHO, 2010, p. 9).

Additionally, telemedicine programs may have a goal to increase access to experts and specialists in shortage areas for organizations that cannot recruit specialists to their facility, reduce costs and improve efficiency, or improve access to providers for acute care or ongoing monitoring of chronic conditions. Telemedicine can also provide cost savings and benefits to patients living in rural communities. These benefits include less travel time, reduced time off from work, and improved quality of life by having access to specialty care not historically available in rural communities.

History and Major Categories of Telemedicine Applications

In its simplest form, telemedicine is the use of any form of information and communication technology to facilitate the delivery, monitoring, or provision of health care services at a distance. In fact, Alexander Graham Bell's invention of the telephone in 1876 is often credited as the first generation of telemedicine because the basic telephone has been used as a tool to facilitate voice communication between patients and their physicians since its inception. More advanced uses of telemedicine, such as sharing images and remote monitoring, were largely attributed to early space research program and the military and began in the 1960s and early 1970s.

Today, telemedicine varies in the applications and settings in which it is used. The two primary types of applications include (1) store-and-forward or asynchronous, and (2) real-time or synchronous. Store-and-forward telemedicine typically involves the exchange of prerecorded data, pictures, or images between two or more individuals at different times (WHO, 2010). For example, a digital image of a patient's skin might be taken and sent remotely to a dermatologist to view (teledermatology) or one provider might send radiological images to another to review or interpret (teleradiology).

Store-and-forward technology is often used in nonemergency situations using private, secure point-to-point networks.

Real-time, synchronous telemedicine is used when a two-way interactive session is needed, typically in the form of videoconferencing. For example, a specialty physician in an urban tertiary care hospital might consult with a primary care physician in a rural community, using high-speed or dedicated Internet lines and real-time videoconferencing capabilities. Some clinicians use common videoconferencing tools such as Skype™ and Windows Live Messenger. In addition, peripheral devices such as a stethoscope or an otoscope can be linked to computers to aid an interactive examination. Mechanisms may involve regular telephone, fiber optics, satellites, Integrated Service Digital Network (ISDN), broadband, and mobile devices (Davlouros, Ikonomidis, Beratis, Thanopoulos, & Manolis, 2009; Durrani & Khoja, 2009).

Theoretical Framework

Donabedian's structure-process-outcome model of health care quality provides a useful framework for examining the use of telemedicine in the international context. According to this model, the structure, or concrete elements of care including equipment, facilities, and human resources, will have an impact on both the processes and outcomes of care (Donabedian, 1980). Thereby, providing appropriate and high-quality structures, such as telemedicine, will impact the process of care by connecting experts to patients in geographically disparate or emergency settings to allow for use of clinical guidelines and practices for treatment. The combination of this structure (telemedicine) and process (expert consultation/treatment with standardized clinical protocols/best practices) will improve the overall outcomes of care. We use this framework to guide our systematic review of telemedicine in the international context and to report on the current state of the structure and process of each region.

METHODS

To answer the research question, we conducted a literature search using Medline to identify articles that met specified criteria. Specifically, we were interested in articles from the year 2000 to present and searched terms including telemedicine (exploded into telepathology and teleradiology), adoption, barriers, utilization, or diffusion, United States, Europe, and Asia. We narrowed our search to include only articles in English, those that

dealt with classification, standards, statistics and numerical data, trends, or utilization, and those with abstracts.

Our search resulted in the identification of 128 unique articles. From this sample of 128 articles, we selected those that had an abstract and were written in English, eliminating 31 of these articles. The three authors met to discuss criteria for inclusion in the study for the remaining 97 articles. Articles were included if they were research focused, provided results/findings, evaluated or reported on a specific telemedicine program, and focused on one of the three regions. Articles were excluded ($n = 45$) for lack of relevance, namely, because they focused on the role of informatics in health professions education, reported on the use of a single product or device, summarized use of unrelated technology (e.g., Smarthome), simply summarized general telemedicine information, discussed a geographic

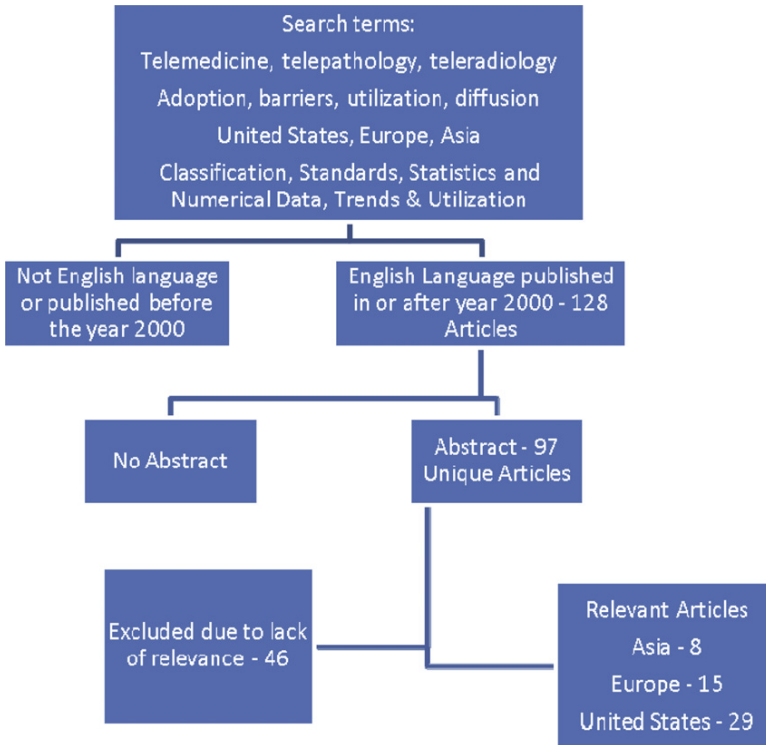


Fig. 1. Sampling Scheme.

region outside of our scope, or did not have an evaluation component. Our final sample included 52 unique articles: 8 relevant articles for Asia, 29 relevant articles for the United States, and 15 relevant articles for Europe. This sampling approach is illustrated in Fig. 1. Data from the articles were extracted for relevant points and information and added to a chart used for the analysis. The chart included the citation, year, sample size, condition treated with telemedicine, methodology, region, and findings. We also noted in the chart a reason for exclusion if articles did not meet criteria for inclusion. The group met regularly to discuss the findings and reasons for exclusion of articles. Once the chart was complete, the analysis began in that the trends, use, similarities, differences, and challenges were compared and summarized, providing quantifiable evidence when possible. Once analysis of the chart failed to produce additional, unique findings, and thus our analysis ceased. We describe our results below and provide a summary of the regions in Table 1.

RESULTS

Overview of Telemedicine Uses Internationally

In Asia

Telemedicine use in Asia varies considerably by region and includes both store-and-forward and real-time synchronous applications. Among Asian countries, an earlier review found that the largest number of telehealth studies were published in Japan (37%), and the store-and-forward modality (43%) was the most common approach, with 35% using videoconferencing and 15% using a combination approach (Durrani & Khoja, 2009). ISDN and conventional telephone lines with a few satellite connections in remote areas were more prevalent in poorer countries, while broadband and wireless connections are used more often in wealthier countries (Durrani & Khoja, 2009).

Countries such as India and China, which have diverse landmass and huge population, are ideal settings for telemedicine. Almost 75% of the population in India resides in rural areas that lack access to health care expertise and infrastructure (Mishra, Kapoor, & Singh, 2009). Therefore, state governments of India are working with central government to build the infrastructure to connect hospitals and health care providers to remote communities via telemedicine. For example, the Department of Information Technology in India has recently formulated a proposal to establish 100,000

Table 1. Summary of Findings.

Region	Use	Conditions	Future	Barriers
United States	Limited international use across borders, used to address geographic challenges, address provider shortages in rural areas, in prisons, in military populations such as veterans, activities not related to direct patient contact including education, tumor boards, and emergency preparedness planning.	<p><i>Acute</i> – asthma, psychotic episodes, heart failure, stroke, neonatal cardiology, and leukemia.</p> <p><i>Chronic</i> – epilepsy, congenital heart disease, digestive disorder, coagulation abnormality, obesity, attention deficit hyperactivity disorder (ADHD), anxiety, bipolar disorder, depression, adjustment disorder, developmental disorder, disruptive disorder, chronic obstructive pulmonary disease (COPD), diabetic retinopathy, hypertension, and diabetes.</p> <p><i>Services</i> – intensive care (ICU), radiology, psychiatry, hospice, pediatrics, oncology, maternal and child health, chronic disease prevention, health promotion, fall prevention, orthopedics, cardiology, dermatology, endocrinology, gastroenterology, hematology, nephrology, pharmacy, infectious disease, ear, nose, and throat services, and counseling for physical activity/exercise.</p>	Some networks closing and unsustainable while others project increased growth in size of networks, demand for services, and number of network.	Licensure, liability, high staff turnover at cites, scheduling challenges between providers, the lack of reimbursement mechanisms, technical challenges, no physical examinations, not seeing a patient face-to-face, interoperability with existing HIT systems, cost to start and implement a system, the lack of training for staff, vulnerability in security, and additional time needed to implement and use a telemedicine system for providers.

Asia	<p>Use both store-and-forward and real-time synchronous applications to provide health care services to rural communities where the majority of population reside. Most telemedicine programs are hospital-based with government support.</p>	<p><i>Acute</i> – heart failure, stroke, epilepsy, acute conditions that require emergency medicine. <i>Chronic</i> – diabetes, heart conditions. <i>Services</i> – radiology, psychiatry, dermatology, cardiology, ophthalmology, neurology, pathology, emergency medicine.</p>	<p>Emerging technology industry; high demand for services in rural communities; a number of initiatives underway by both private and public sectors; task force has developed standards that should help promote adoption and use; increased opportunities for further research.</p>	<p>Medicolegal and licensure issues: credentialing, malpractice. Telecommunications infrastructure and standards: interoperability, scalability, security, reliability, and accessibility of infrastructure in rural communities; Costs and reimbursement – initial and reimbursement – initial and ongoing costs, financial incentives for physicians as well as time, reimbursement issues; Support staff – lack of sufficiently trained support staff.</p>
Europe	<p>Programs in place provide patient/physician consultations, physician-to-physician consultations, and remote monitoring of patients. Work has been done in specific fields such as telepathology, teleradiology, and tele-echocardiography.</p>	<p><i>Acute</i> – childbirth, heart failure. <i>Chronic</i> – congestive heart failure, chronic obstructive pulmonary disease. <i>Services</i> – psychiatry, emergency medicine, teleradiology, telepathology, tele-echocardiography, dermatology, traumatology, endocrinology, and rheumatology.</p>	<p>No standard communication/language between countries, lack of user trust and training, lack of reimbursement and funding, lack of interoperability capabilities, fear of unknown consequences such as competition and increased workload.</p>	

Common Service Centers in rural communities that would connect citizens to the Internet and provide front-level government services such as health care (Bedi & Tech, 2009). An earlier study of telemedicine diffusion in India identified the factors critical to its success, pointing out the importance of setting clear program objectives, garnering government support, adapting user-friendly interfaces, ensuring adequate connectivity, implementing standards and protocols, and measuring cost-effectiveness and user satisfaction (Pal, Mbarika, Cobb-Payton, Datta, & McCoy, 2005). Misra, Kalita, Mishra, and Yadav (2005) found that telemedicine has enormous potential in neurology for treating status epilepticus and stroke but is greatly underutilized, particularly in India. One study examined physician opinions of telemedicine at 14 different hospitals in India (Meher, Tyagi, & Chaudhry, 2009). Approximately 25% of physicians indicated they were interested in telemedicine but expected reimbursement for practicing via this modality. Their current workloads are high and finding time to see patients remotely via telemedicine is difficult (Meher et al., 2009). Patients participating in the study, however, felt that telemedicine increased access, and saved time and money (Meher et al., 2009).

Telemedicine emerged in China in the mid-1980s, primarily through the use of store-and-forward technology. Real-time synchronous telemedicine was rare because the supporting telecommunications infrastructure did not exist. In fact, most of the early telemedicine initiatives in China were US–China Internet-based consultations (Xue & Liang, 2007). Today, China has at least three main major telemedicine networks, the Golden Health Network, the International MedioNet of China network, and the People’s Liberation Army telemedicine network. Examples of telemedicine uses within these networks include diagnosing, consulting, image interpretation, and patient monitoring (Xue & Liang, 2007). Telemedicine use in China has its limitations though. Cost, traditional values, physician motivation, and lack of information technology staff to support telemedicine in hospitals are all critical issues. Most Chinese people cannot afford telemedicine, and patients prefer to be seen face to face with their provider (Xue & Liang, 2007). Additionally, there are no incentives for physicians to use telemedicine when they are paid the same salary whether they use it or not.

Taiwan only fairly recently began to explore and use telemedicine for patient care purposes. One of the largest projects to date is a telehealth project known as the Development of a Telehealth Center for Discharged Patients, developed by the National Taiwan University Hospital (NTUH) (Wu et al., 2010). Patients who are discharged after surgery or a serious medical crisis are monitored through an intelligent remote health care

monitoring system. The four categories of patients included in the initial project are post-hospitalization care, integrated management of cardiovascular diseases, integrated management of chronic diseases, and hospice management. These categories were selected because patients in these groups tend to experience higher rates of emergencies and distance to providers tends to be a barrier to their care (Wu et al., 2010). They conducted a heuristic evaluation of the system and found it to be fairly easy to use and navigate. The program has fulfilled its original goal of delivering follow-up hospital services while reducing costs, although the report does not indicate its extent.

Five of the eight articles identified the major barriers to the widespread growth of telemedicine in Asia (Bedi & Tech, 2009; Durrani & Khoja, 2009; Meher et al., 2009; Misra et al., 2005; Xue & Liang, 2007). These barriers included the need for telemedicine standards and guidelines; privacy and confidentiality of individual health data; interoperability and scalability across telemedicine services within the country and internationally; costs; reimbursement issues; untrained support staff; inadequate telecommunications infrastructure in rural communities; malpractice, and other legal issues. Patient satisfaction with telemedicine is not well known. Only one of the eight Asia articles assessed patient satisfaction with telemedicine; the number of patients who had prior experience with telemedicine was limited to 7, limiting the generalizability of results (Meher et al., 2009).

In Europe

Over the past decade, there have been a number of different telemedicine projects throughout Europe including work in the fields of teleradiology, telepathology, and tele-echocardiography. The applications, aims, and objectives of these projects are varied throughout the continent, but they shared the same overall goal, improving the provision of patient care, and many faced the same barriers to widespread use.

In the United Kingdom, a pilot project was carried out in which patients, with a general practitioner present, were provided teleconferenced psychiatric consultations. The project sought to address clinical need, explore new technologies, move toward primary care services that were based locally, and increase cooperation between organizations that were part of the National Health System (Cornford & Klecun-Dabrowska, 2001). Another project in the same area included a Women and Children's Centre, which was staffed by midwives and nurses, and had a telemedicine link to a separate hospital. Patient information and ultrasound images belonging to patients in the Early Pregnancy Assessment Unit could be viewed live from

the hospital where a doctor could provide his/her professional opinion to the midwives. There were also videoconferencing facilities and store-and-forward technology, which could be used (Cornford & Klecun-Dabrowska, 2001). In the end, neither of these projects was sustainable for a long period of time because either they did not become part of the health care routine or there was not sufficient funding in place for the project to continue.

In Germany at the University of Regensburg Medical Center, there were over 40 telemedicine projects and plans underway at the end of the year 2000, with applications ranging from emergency medicine to teleconsultation to telemonitoring. The NOAH (Notfall Organisations- und Arbeits-Hilfe) project simplifies the transfer of patient data from a wearable computer at the scene to the doctor in the event of an emergency situation. The project allowed for improved data reliability and time for the hospital and physician to prepare (Nerlich & Schall, 2003). Another project underway is the Eastern Bavaria hospital network, which has been underway since 1998, run as a secure intranet, and has 80 participants from 50 hospitals. Teleconsultations between physicians at different hospitals are carried out via the network providing expertise that may not be locally available (Nerlich & Schall, 2003). The "Citizen Health System," a European Union project in cooperation with the United States, includes a home monitoring system for patients discharged from postoperative inpatient care. A nursing service looks after the patients, records their progress, and transmits the data back to the treating physician (Nerlich & Schall, 2003).

Telepathology has been another area of focus across Europe. One example of this is the COST Action 130604 "Telepathology Network in Europe," or EURO-TELEPATH, one of the main objectives of which is to integrate digital pathology slides into the electronic health record. Other research directions include automation procedures in pathology, international standards and health information exchange initiatives, and a European-scope telepathology network. A major barrier to integrating digital slides into the electronic health record currently is the cost of digital slide scanners (Rojo, Castro, & Goncalves, 2011). Despite the benefits of telepathology and research into its use, its spread has been stymied by a number of other barriers including a large time requirement, lack of reimbursement, and a fear of competition (Mairinger, 2000).

Another area of focus in terms of telemedicine in Europe has been tele-echocardiography, specifically in Italy. The telecommunication network has evolved over time and greater technological capabilities have led to the promising digital tele-echocardiography. Digital tele-echocardiography has

seemed to show advantages over the traditional videotape recording and has been shown feasible in emergency care (Giansanti & Morelli, 2009). A successful clinical application of tele-echocardiography included a tele-consultation project where consultations could be made both in real time and on a scheduled regular basis (Frumento et al., 2009). Giansanti et al. developed a structured methodology for a health technology assessment of tele-echocardiography products. The system for assessment was based on an interactive questionnaire and checklist, which allows the comparison of products that meet the minimum level of acceptance (2009).

In the field of teleradiology, a barrier to the use of telemedicine across borders is the difference in language between providers and patients or providers and other providers. One of the largest challenges discovered in a study comparing two teleradiology projects in Europe was the fact that none of the institutions participating in the projects spoke the same language (Ross, Sepper, & Pohjonen, 2010). In an attempt to overcome this challenge, radiologists participating in one of the projects created a “structured multilingual reporting tool” (SRT) that used a structured reporting template and pull-down menus of multiple choices that were then automatically translated into the required language. However, this had limited success because the SRT only covered the hip and knee as it was difficult and time-consuming to add another anatomical region. The study also reported that approximately 20% of the SRT reports had to be translated by an interpreter because they lacked a particular descriptive sentence (Ross et al., 2010). The study found that “the lack of automatic translation tools is the main obstacle for development of cross-border teleradiology in other countries than United Kingdom or United States, or neighbouring countries with relative languages” (Ross et al., 2010, p. 24).

Much of the research on telemedicine in Europe has been in the United Kingdom and has centered on user acceptance and perception of telemedicine. Four articles were found describing research done on how users of telemedicine feel about the technology. Tachakra, Habashy, and Dawood (2001) analyzed the questionnaire responses of 90 emergency nurse practitioners in 11 British minor injury units. The questionnaire included questions about changes in attitudes, education and skills, work, and relationships since the respondents began using telemedicine. In terms of changes in attitudes, a large majority of respondents said they were more open to change and ready to grasp opportunities. It was also found that a majority of respondents were keen to learn new things, had adopted a more advisory and supportive role, and worked as a team with no actual “ownership” of patients. When asked about relationships, 86%

said that the power balance with doctors had changed and 69% said doctors indulged in more dialogue than direction (Tachakra et al., 2001). Sixteen clinical users participated in focus group discussions aimed at recording their perspective on telemonitoring patients (Sharma, Barnett, & Clarke, 2010). The authors found three main themes – conflict and contradiction, trust, and security. Their main concerns were that telemonitoring is not adequate to discover underlying infections and might lead to less face-to-face interaction, increased their work load, may not be reliable or used appropriately, and that patients may start depending on the equipment long term and may be faced with lack of availability (Sharma et al., 2010).

In a survey of doctors and nurses in rural general practices in the United Kingdom, Richards et al. found that a majority of respondents who had used eHealth (telemedicine) to transmit data or communicate had used it for communication. The authors found that the most important barriers to implementation were lack of training, equipment cost, and increase in workload, and found that eHealth was rated more positively for education than clinical uses (Richards et al., 2005). Lam and MacKenzie (2005) came to similar conclusions when conducting a field study to examine the use of telemedicine in US military clinics and hospitals throughout Europe. Users interviewed reported a perceived increase in workload without an increase in compensation, felt that there was lack of experience with telemedicine, and expressed that videoconferencing could be used for education. The authors also found the lack of consistent and central leadership to be problematic (Lam & MacKenzie, 2005).

Dennis, Start, and Cross (2005) found in a survey of pathologists that only 8% had a commercially produced telepathology workstation, 14% had video conferencing equipment, and 12% of respondents said they used a full telepathology workstation in another laboratory or their own. A majority of respondents said that if they did have a telepathology facility, they would use it for attendance at multidisciplinary team meetings or for referral of cases for expert opinions. The most important disadvantages to telepathology for the respondents were insufficient image quality and medicolegal implications of duty of care. Overall practical experience with telepathology was uncommon in pathologists in the United Kingdom and few had been able to access training (Dennis et al., 2005).

Research was also done in Spain to study the impact of telemedicine on the quality of life in rural areas. Out of 800 primary care patients, 420 had regular face-to-face hospital referrals and 380 were referred to a hospital specialist at a distance using telemedicine (Ferrer-Roca,

Garcia-Nogales, & Palaez, 2010). Both groups had comparable health status at the end of the trial, but the patients using telemedicine had better quality of life because their traveling was limited and they were diagnosed, examined, and treated faster than the patients who were treated face-to-face (Ferrer-Roca et al., 2010).

Although Europe has seen a wide variety of telemedicine projects and research over the past decade, 7 out of 15 articles described similar barriers, including the lack of funding and/or reimbursement, lack of standardization, lack of training, and lack of user acceptance possibly due to fear of unknown consequences (Cornford & Klecun-Dabrowska, 2001; Dennis et al., 2005; Lam & MacKenzie, 2005; Mairinger, 2000; Richards et al., 2005; Sharma et al., 2010). To help overcome the barrier of lack of user acceptance, Huis in 't Veld et al. (2010) formulated a guideline for a multidisciplinary approach to designing new teleretreatment services, specifically in telerehabilitation. The involvement of users in the development of new services is difficult because of the knowledge gap between those using the service and those designing the service. Their guideline aims to bridge communication and language and methodological gaps that are commonly faced in telemedicine design (Huis in 't Veld et al., 2010).

In United States

Much of the use of telemedicine in the United States addresses the shortage of providers and specialists in rural areas. To highlight this issue, one study stated that, "rural America has 20 percent of the population, but <11 percent of the physicians, and this imbalance is worsening" (Singh, Mathiassen, Stachura, & Astapova, 2010, p. 986). This is especially evident given that 7 of the included 29 US studies focused on rural use of telemedicine. Telemedicine is also used in the United States to provide specialty care to patients that have limited access for geographic or other reasons, and we found evidence that telemedicine is used in such settings as prisons (Rheuban, 2006) as well as in military health care settings (Bangert & Doktor, 2000). Telemedicine has also been used for activities not related to direct patient contact including education, tumor boards, and emergency preparedness planning (Grigsby, 2002; Neuman, 2006; Singh et al., 2010), and is used in both a synchronous and an asynchronous manner. In the United States, the synchronous applications of telemedicine appear to connect providers to patients at other provider organizations, whereas the asynchronous applications connect patients to providers directly.

Despite the increased use of telemedicine that was cited in several articles, barriers in the use of telemedicine persist (Grigsby, 2002). These include licensure, liability, high staff turnover at sites, scheduling challenges between providers, the lack of reimbursement mechanisms, technical challenges, no physical examinations, not seeing a patient face-to-face, interoperability with existing HIT systems, cost to start and implement a system, the lack of training for staff, vulnerability in security, and additional time needed to implement and use a telemedicine system for providers (Berenson, Grossman, & November, 2009; Daly, 2000; Helitzer, Health, Maltrud, Sullivan, & Aleverson, 2003; Hopp et al., 2006; Marcin et al., 2004; Menachemi, Burke, & Ayers, 2004; Whitten & Mackert, 2005). Of these barriers, financial considerations are perhaps the greatest barrier and were mentioned as specific challenges in 5 of the 29 US studies. Suggestions for overcoming these barriers include developing a mutual recognition of licensing laws, development of a universal standard of care, getting provider buy-in, identifying a champion or a leader to promote and support the system, providing adequate training and support, promoting collaboration, developing shared vision, exploiting funding opportunities, cultivating participation, identifying critical services, developing alliances in the community, improving related administrative processes, securing ongoing future funding and support, and exploring incentive-based strategies for increased use (Cook & Whitten, 2002; Daly, 2000; Helitzer et al., 2003; Singh et al., 2010; Whitten, Doolittle, & Mackert, 2005).

Several of the articles focused on the provider perceptions of the use of telemedicine. For example, one article in the United States found that staff involved in the project thought that telemedicine was easy to use and enabled a wider reach for patients (Miake-Lye et al., 2011). Another study on the use of telemedicine in the United States to provide in-home hospice care showed that concerns about telemedicine use were related to the nature of specific aspects of the job such as autonomy and mileage reimbursement (Whitten et al., 2005). This same article showed a relationship between provider experience with telemedicine and perception, showing that more experienced telemedicine providers were more comfortable with the equipment, ranked it easier to use, and thought it was a good way to provide care. In the intensive care unit (ICU) in the United States, staff believed that telemedicine use improved quality and safety of care (Berenson et al., 2009). Other articles used reported on individual experience to provide information about best practices in the development and sustainability of telemedicine networks such as provider buy-in, securing support for future funding, providing training and

support, and to use a motivation to improve clinical quality and patient safety to get staff on board (Berenson et al., 2009; Helitzer et al., 2003; Singh et al., 2010).

Other studies focused on patient perceptions of telemedicine use. For example, in the United States, Miake-Lye et al. reported that elderly patients who received fall prevention education through telemedicine felt better prepared with home safety and prevention and that they were more alert (2011). Also in the United States, Tran and colleagues found that patient participants in a telehome health care focused on hypertension and diabetes experienced significantly greater self-management knowledge, self-efficacy with managing their illness, and positive perceptions of the use of telemedicine (2009). Kaufman, Starren, and Patel report that in the United States, literacy is an important factor in predicting how well and likely elders are to use home telemonitoring for diabetes (2003). Overall, many of the US telemedicine studies indicated patient satisfaction with telemedicine because of reduced travel time, increased access to specialists, they didn't have to miss work for an appointment, if they could see the specialist very well and that they got the best care (Marcin et al., 2004; Myers, Valentine, & Melzer, 2008). Disadvantages from the patient perspective in the United States include not seeing a provider face-to-face, no physical examinations, and a fear that a doctor wouldn't tell the truth if you aren't face-to-face (Marcin et al., 2004). Despite these disadvantages, in the United States, Marcin et al. found that the majority of patients ranked their satisfaction with telemedicine as excellent or very good, and half were very likely to use telemedicine in the future when available (2004). Given the focus in the United States on patient-centered care, we find that 6 of the 29 articles from the United States focused on patient satisfaction or perceptions of care through telemedicine.

Only one article reported on the use of a nongovernmental US telemedicine network internationally. Kennedy (2000) reported on the use of workshops, case studies, demonstrations, and interactive discussions to promote better maternal and child health in Slovakia. Overall, we find limited evidence in the literature of the use of telemedicine internationally from the United States. A report by the American College of Radiology outlined many of the challenges associated with international teleradiology. Issues such as credentialing, quality assurance, licensure, jurisdictional and medical liability issues, patient privacy, fraud, and medical ethics will likely limit widespread international teleradiology initiatives until these concerns are appropriately addressed (Moore, Allen, Campbell, Carlson, & Dunnick, 2005).

CONDITIONS

In Acute Care Settings

In the United States, telemedicine is used to treat several acute conditions including asthma, psychotic episodes, heart failure, stroke, neonatal cardiology, and leukemia (Grigsby, 2002; Hopp et al., 2006; Marcin et al., 2004; Myers et al., 2008; Redina et al., 2001). One example is that telecardiology has been used in neonatal intensive care units to monitor infants with heart problems and has shown to reduce the rate in which infants are transferred to academic medical centers resulting in significant cost savings (Rendina, Narrasco, Wood, Cameron, & Bose, 2001). The use of telemedicine to treat acute care settings is generally intended to reduce burden on the provider hospitals that cannot afford to staff around the clock expertise in each specialty area while also providing high-quality care to patients who need emergency access to such specialty expertise. We find that these telemedicine arrangements often take a hub-and-spoke format and that the driving force is a desire to improve quality of care in a cost-effective manner. However, de la Torre and colleagues found that such use of telemedicine is not always cost-effective and that telemedicine consultations in some sites can be more costly than conventional consultations (de la Torre, Hernandez-Rodriguez, & Garcia, 2004). Telemedicine in the United States is also likely used to treat other conditions since a study suggested that tele-emergency systems were used by a portion of US hospitals, but without specifying which conditions were treated (Mena-chemi, Brooks, Schwalenstocker, & Simpson, 2009). Two specific neurological conditions that are ideally suited for telemedicine intervention in Asia include epilepsy and acute stroke, yet according to Misra et al. (2005) telemedicine is not as widely used to treat these conditions as it could be. In Europe, telemedicine has been used to treat those with heart failure and pregnant women (Cornford & Klecun-Dabrowska, 2001; Giansanti & Morelli, 2009).

In Chronic Condition Settings

Telemedicine is also used to treat a number of chronic conditions in the United States including epilepsy, congenital heart disease, digestive disorder, coagulation abnormality, obesity, attention deficit hyperactivity disorder,

anxiety, bipolar disorder, depression, adjustment disorder, developmental disorder, disruptive disorder, chronic obstructive pulmonary disease, diabetic retinopathy, hypertension, and diabetes (Carroll, Cullen, Ferguson, et al., 2011; Chumbler et al., 2005; Hopp et al., 2006; Marcin et al., 2004; Myers et al., 2008; Tran, Buckley, Bertera, & Gonzales, 2009). The number of chronic conditions treated with telemedicine in the United States is likely a function of the high incidence and prevalence of such chronic conditions and the belief that more frequent contact with patients to monitor such conditions (process) can be provided through telemedicine (structure), and will lead to better management (outcomes). Telemedicine is used in the care of chronic heart failure and chronic obstructive pulmonary disease in Europe (Sharma et al., 2010). Examples of telehealth being used to monitor patients with chronic illness from home in Asian countries were mentioned in the literature but were limited (Durrani & Khoja, 2009).

In Services

Specific services offered through telemedicine in the United States include intensive care (ICU), radiology, psychiatry, hospice, pediatrics, oncology, maternal and child health, chronic disease prevention, health promotion, fall prevention, orthopedics, cardiology, dermatology, endocrinology, gastroenterology, hematology, nephrology, pharmacy, infectious disease, ear, nose, and throat services, and counseling for physical activity/exercise (Berenson et al., 2009; Carroll et al., 2011; Farzanfar, Frishkopf, Migneault, & Friedman, 2004; Grigsby, 2002; Helitzer et al., 2003; Kennedy, 2000; Lewis, Sunshine, & Bhargavan, 2009; Marcin et al., 2004; Menachemi et al., 2009; Miake-Lye et al., 2011; Singh et al., 2010; Spaulding, Belz, DeLurgio, & Williams, 2010; Whitten et al., 2005; Whitten & Mackert, 2005). However, the two most frequently cited services provided through telemedicine in the United States were mental health and radiology (Lewis et al., 2009; Menachemi et al., 2009). In Asia, telemedicine is used to treat patients in specialties such as radiology, psychiatry, dermatology, cardiology, ophthalmology, neurology, pathology, and emergency medicine (Durrani & Khoja, 2009; Misra et al., 2005). In Europe, telemedicine services offered include psychiatry, emergency medicine, dermatology, traumatology, endocrinology, rheumatology, pathology, and radiology (Cornford & Klecun-Dabrowska, 2001; Dennis et al., 2005; Ferrer-Roca et al., 2010; Mairinger, 2000; Nerlich & Schall, 2003; Rojo et al., 2011; Ross et al., 2010).

FUTURE

There are varying future projections for the use of telemedicine in each of the three regions. While there is potential for telemedicine to deliver timely expert care to patients in a convenient manner and a cost-effective way, the literature in the United States reported at least one telemedicine network reported on was closed by the publication of the findings due to a lack of leadership and support for the program (Miake-Lye et al., 2011). Two articles in the European literature similarly reported that projects or programs were ended or went unused due to a lack of routine use, support, and leadership for the project or program implemented (Cornford & Klecun-Dabrowska, 2001; Lam & MacKenzie, 2005). Also in the United States, one study reported that the number of networks, size of networks, and demand for services is increasing over time (Grigsby, 2002), and another study projected that telemedicine is expected to grow (Hopp et al., 2006). The literature provides several suggestions for the development of individual networks, and two studies suggest that the use of incentives to promote provider acceptance should be explored since telemedicine has not grown as much as expected (Cook & Whitten, 2002; Whitten & Mackert, 2005). Given these varying projections and experiences with telemedicine, its future use is uncertain and seems contingent upon the better development of structure and processes to support its use.

DISCUSSION

There are varying structures in the use of telemedicine among the regions. Although each region uses both synchronous and asynchronous technologies, telemedicine is used in Asia and Europe primarily to connect provider organizations to other provider organizations to treat patients while in the United States we find that there is more use of provider to patient connection via telemedicine. Articles from Asia specifically mentioned challenges related to the reliability and accessibility of infrastructure in rural communities. The increased use of telemedicine in the United States to connect patients to providers may be reflective of the populations in each region given that the United States has a stronger infrastructure to provide care directly in patient's homes (high-speed Internet capabilities and frequency of use) as well as the fact that patients in the United States focus more on patient-centered care, and US patients have high comfort levels with the use of technology. In support of this point, we find that

articles in the United States were more likely to consider this patient perspective and report positively on patient satisfaction with telemedicine while articles in Europe and Asia were more likely to report on provider satisfaction than patient satisfaction with telemedicine. Overall, each region noted that providers were satisfied with telemedicine use despite perceptions that patients may prefer face-to-face treatment.

The varying structures of telemedicine in each of the three regions impact the process of treatment for specific conditions. For example, in the United States, we find evidence of many more chronic conditions being treated through telemedicine than in Europe or Asia. This may be the result of patients in the United States suffering frequently from chronic conditions that need more frequent monitoring, and telemedicine provides greater access for such monitoring in addition to the increased structure that US patients have based on access to technology. We find that similar services are provided through telemedicine in each of the regions including radiology, psychiatry, dermatology, cardiology, neurology, and emergency medicine. Not surprisingly, we find that more acute and chronic conditions are named in articles to be treated in the United States compared to Asia or Europe, and this may be the result of increased frequency or prevalence of telemedicine use, based on number of reporting articles in that region.

All three regions reported heavily on the barriers facing the development and use of telemedicine, and these barriers impact both the structure and process of telemedicine use. Specifically, we find that each region faces issues in licensure, liability, reimbursement, technical challenges, security concerns, cost to start and maintain a system, increased staff or provider time required, and a lack of training or support. Both Asia and Europe, however, faced unique challenges given the diversity of languages spoken in those regions as well and a lack of credentialing between countries.

In the literature, we found many of the studies in each region were either summaries of specific programs or qualitative evaluations of very small sample sizes (Cook & Whitten, 2002; Cornford & Klecun-Dabrowska, 2001; Daly, 2000; Frumento et al., 2009; Giansanti & Morelli, 2009; Helitzer et al., 2003; Marcin et al., 2004; Meher et al., 2009; Miake-Lye et al., 2011; Nerlich & Schall, 2003; Rojo et al., 2011; Singh et al., 2010; Spaulding et al., 2010; Whitten & Mackert, 2005). For example, in the United States, Whitten and Adams provided a case study of the use of telemedicine between Marquette General Hospital and Beaver Island to overcome challenges of access in a rural region (2003). Mishra et al. (2009) provide a brief narrative inventory of telemedicine initiatives across India pointing out that no single entity oversees the plethora of programs. Various states in

India, for example, work in conjunction with the central government to establish telemedicine networks and connect hospitals. We could find little evaluative information about each one beyond a brief description. In Europe, two articles provided frameworks for assessing/implementing telemedicine programs or projects (Giansanti et al., 2009; Huis in 't Veld et al., 2010). Sharma et al. (2010) report findings based on focus group sessions with only 16 participants and Lam and MacKenzie (2005) cite interviews but provide no sample size. This finding indicates that there are gaps in the literature of valid, rigorous, generalizable, large studies evaluating telemedicine use. Given that telemedicine use is still in its infancy in many areas, there is great future opportunity for such study.

CONCLUSION

First, we find that there is a great variation in the use of telemedicine among the United States, Asia, and Europe. These differences lie in the conditions treated, services offered, areas studied, and overall uses of telemedicine based on region. In the United States, for example, the focus is on treating chronic conditions with less use for acute care conditions. Likewise, in the United States, telemedicine is used for activities outside of direct patient care such as education, planning, and meetings. Based on the sheer number of articles, telemedicine appears to be used more frequently in the United States. The demand for telemedicine appears to be high in many regions of Asia, particularly in India and China, where a large proportion of the population lives in rural communities, often with limited access to needed specialty health care providers and services. In Europe, many users of telemedicine are interested in possible educational opportunities and the change to increase communication and/or consulting with other health care providers. Its use in chronic care is limited but a large variety of services are provided and utilized.

Second, our analysis also shows that telemedicine use and networks in each of the regions face very similar barriers in use. In the United States, for example, the greatest barrier, as indicated by the number of articles mentioning it, is financial support/reimbursement. Lack of Internet access and telecommunications support seems to be a larger barrier in rural parts of India and China than in rural communities in America. Yet issues such as physician licensure or credentialing, liability issues, having available sufficiently trained support staff and patient privacy and security concerns appear to be universal concerns to all. Each barrier represents a structure or

process that needs to be addressed in order to allow telemedicine use to realize its full potential.

Third, telemedicine in the international context is still an area of development. Although we used Donabedian's structure-process-outcome model to guide our study, we found that many of the telemedicine networks in each of the regions are still struggling with the development and use of the structure (telecommunications infrastructure and equipment) to use telemedicine. Given this challenge, and all of the barriers and challenges that providers face in developing and using telemedicine, we believe that the processes and outcomes will be impacted potentially negatively. However, there are indications in the literature that telemedicine is increasing in prevalence and applications in each region, and thus, once these structures are more developed, the potential for the use of telemedicine within nations, regions, and the world will be great. However, the persistence of these issues indicates that not only is the telecommunications infrastructure and support needed, but so too are trained support staff and expertise to assist clinicians with adoption and effective use of the technology. Beyond the development of the technological structure and alliances between organizations for the further development of telemedicine, each region needs to consider strategies for financing and incentivizing the use of telemedicine, licensure and credentialing across borders, and the development of standards of care using telemedicine. In Asia and Europe, the lack of a common language is particularly challenging, and interpretation services may be needed for increased use.

Finally, given the current nature of the telemedicine literature, there are certainly gaps in the literature particularly in large sample empirical studies showing the benefits or barriers to the use of telemedicine. While the literature included allowed for a glimpse into the current state of telemedicine use and a comparison internationally, future research should attempt to provide rigorous empirical studies that allow for more generalizable findings. This will be a challenge given the varying nature of telemedicine systems, slow diffusion and development of use, uses, and populations served.

Our study does have limitations. First, we are comparing three diverse regions, each of which is also full of diverse populations and locales, and the nature of such diversity will certainly impact how telemedicine is used. We are aware of these differences and have attempted to use them to describe the varying types of potential that telemedicine has when it is fit to the patients served. Second, many of the studies were merely descriptive in nature, and several others were simply summaries. We have excluded articles

that we deemed to be irrelevant and have corroborated to ensure uniformity in such selection. Yet, our analysis is only as strong as the articles we include. Third, there are differences in the numbers and quality of articles found in each region. For example, there were many more articles included for the United States than for Asia, and although our literature search was systematic and we attempted to balance information about the three regions, it is possible that our analysis provides more information about use of telemedicine in the United States. Finally, telemedicine is a rapidly changing technology, and it is likely that there is a lag time between use of telemedicine, study of its application and outcomes, and publication of such findings. Thus, it is possible that there are new applications or networks currently in use that have not been included here. We have attempted to overcome this by using the most recently published papers.

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MOBILE IT SOLUTIONS FOR HOME HEALTH CARE

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ABSTRACT

Purpose – Harnessing the advantage of mobile information technology (IT) solutions at the point of care and contributing to patients' safety by involving them.

Design/methodology/approach – International collaboration between specialists in health communication processes and information management and systems.

Methods used – Case studies, design science.

Findings – User-friendly portable IT applications going beyond documentation of patient records and administration require an understanding of complex communication processes between patients and the different caregivers. Home care increasingly faces structural deficits to be mitigated by integration of IT solutions. Platforms chosen in combination with services should be well established. How to implement this must be scrutinized by comprehensive research as initiated here. Preliminary results indicate potentials for novel mobile applications.

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Practical implications – *Contribution to increasing patients' safety by developing mobile solutions to support health care. Those may also contribute to cost savings in health care.*

Social implications – *Health care experiences an increasing significance for Western industrialized countries because of demographic developments. Care generally shifts from inpatient to outpatient settings; the global shortage of qualified nurses becomes even more prevailing. More support, among others by IT and enhanced interprofessional communication, is demanded for an improved quality and efficiency of care processes.*

Originality/value – *Mutual approach benefits from the partner's understanding of complex interactions among clinicians, health services, and patients: the ability to design, monitor, and evaluate research strategies integrating care (information) needs is invaluable when applying creative technology solutions within health care domain.*

Keywords: Patient care; international collaboration; IT application; health communication; processes

INTRODUCTION: IT AS AN ENABLER IN HEALTH CARE

In recent years, the challenges facing health care have increased in significance for postindustrial governments and local policy makers for reasons that are financial, demographic, and technological (Kung & Jean-Bart, 2010). Postindustrialized countries such as Australia face an aging population (with the number of elderly above 65 almost doubling to 25% by 2040), and rising levels of chronic disease and multimorbidity (AIHW, 2007). These developments are complicated further by a global shortage of qualified caregivers (Simons, Egami, & Perry, 2007). For its part, Germany will have 3 million inhabitants by 2040 that are estimated to be in need of some kind of nursing – an increase of nearly 150% compared to today's level (Statistisches Bundesamt, 2009).

A critical means to managing these challenges in the health care industry is to generate detailed and extensive medical, scientific, and bureaucratic information. Because the churn affecting knowledge work is causing problems for organizations as staff movements lead to corporate loss of know-how, knowledge management is an increasingly significant concern

(Perrot & Iedema, 2009). No doubt, then, to countervail this instability, it is critical that health care knowledge and data need to be collected, managed, stored, and disseminated to ensure services become knowledge-intensive health care organizations. In the past, these organizations have been slow to act (Perrot & Iedema, 2009).

To aid in this process, and to facilitate knowledge production and transfer, more information technology (IT) support is needed (Brettlecker et al., 2008; Pryss, Tiedeken, Kreher, & Reichert, 2011; Reichert, Peleg, & Lenz, 2008). Health care has adopted IT for many processes (Breitschwerdt, Robert, & Thomas, 2011), but a drawback is that IT use in health care is generally technology driven instead of need oriented (Wyatt & Wyatt, 2003). What further complicates the situation is that health care professionals and policy makers have reason to question the usability of health care IT, given previous failures (Lapointe, Mignerat, & Vedel, 2011). On that basis, Wyatt and Wyatt (2003) and Kushniruk and Patel (2005) advocate continuous IT evaluation, feedback, and adaptation to ensure the potential benefits of IT are not lost, and so that health service users are technologically better supported (Åkesson, Saveman, & Nilsson, 2007).

What has become known as the limited usage criterion also applies to the now widely used mobile devices like laptops (Kosteva, Schaller, Brian, & Strayer, 2005), handhelds, and cellular phones. These devices are deployed in various application areas such as for documentation in hospitals and for communication with clinicians in home care settings. However, many of the solutions being referred to as “mobile” are in fact no more than computer applications ported to personal digital assistants (PDAs) or tablet PCs (Rügge, 2008). Also, there remains a divide between IT supporting organizational processes and IT supporting care processes (Lenz & Reichert, 2007). Therefore, we have to acknowledge that to date mobile solutions have not sufficiently targeted the actual ambulant care but more often the documentation and administrative planning of organizational processes. This points to an unmet need: to design mobile, adaptable, and interactive solutions to capture, accompany, and perhaps even rationalize the complex dynamics involved in care processes (Breitschwerdt et al., 2011).

The approach discussed here seeks to harness the advantages of mobile solutions at the point of care. This aim has the potential benefit of increasing patients’ involvement in their care and, through that, enhancing their safety. Portable solutions need in some way to account for and accommodate the complex dynamics of existing communication processes between patients, general practitioners, and specialists. These solutions may contribute to cost

savings in health care, which often results from increasing patients' involvement in their own care (Hughes & Larson, 1991). At the same time, portable solutions can make use of the growing mobile phone user market (research2guidance, 2010).

This chapter limits its discussion to mobile solutions for home care, and to an exploration of its potential in Australian and German contexts. Home care is rapidly growing due to the rising number of elderly people, and the costs associated with hospitalizing them when they fall ill. In exploring the potential of mobile solutions for the home care sector, this chapter:

- provides an overview of existing related work,
- categorizes existing solutions in terms of their usefulness, and
- deduces a (future) research agenda from our own findings for advancing mobile technology design and obviating technology shortcomings.

HOME CARE AS A FACET OF RISING IMPORTANCE IN HEALTH CARE

Basic Concepts and Background

Home care is experiencing an acute shortage of personnel (Anderson, Jay, Anderson, & Hunt, 2002; Hannah, Ball, & Edwards, 2006; Simons et al., 2007; Statistisches Bundesamt, 2007). One of the challenges of home care lies in the clinician needing to provide care (Wälivaara, Andersson, & Axelsson, 2011) that is at once autonomous and collaborative, individual (targeting patients) and social (partners), and geographically dispersed. Home care nursing moreover includes prevention, health promotion, and care of ill, disabled, and dying people (Kralik & van Loon, 2011). In a home or community setting, periodic visits by a caregiver (or other health care provider) are needed for monitoring and treating people with postoperative or chronic conditions as well as supporting them with domestic activities (Gesundheitsberichtserstattung des Bundes, 2010; Simons et al., 2007).

For these reasons, working in this field requires a high level of flexibility and consists mostly of tasks “on the go.” Due to its mobile character with activities carried out in varying locations, home care is very different from inpatient care in hospitals or in retirement homes (Rügge, 2008). Altogether,

the factors “time” and “mobility” represent increasingly critical aspects of home care. It is here that IT may be able to make a unique contribution (Brettecker et al., 2008).

Among industrialized countries, the United States, Canada, Australia, New Zealand, the United Kingdom, and Germany are among those which suffer from a lack of home care efficiency and quality (Anderson, 2007), especially in ambulatory settings (Jha, Doolan, Grandt, Scott, & Batese, 2008). Whereas IT represents an inherent part of inpatient environments, home care is still underserved (Brettecker et al., 2008). But now that IT has been integrated into portable devices such as “computers on wheels” servicing inpatient environments, and now that services can support mobile data access outside of local area networks as well, IT should be adaptable to fully mobile care provision scenarios (Kafeza, Chiu, Cheung, & Kafeza, 2004).

Purpose and Motivation

Community nursing has been compared to after-sales technical field support (TFS) (Amberg & Augustin, 2011; Rügge, 2008). Both these practices are carried out across locations (Andriessen & Vartiainen, 2006). The primary dimension of such work is performed with the patient of course, but it is critically reliant on administrative tasks that are well suited to virtual IT applications. Additionally, service providers operate on their own or in small teams. Their care tasks may involve making decisions that require technical or scientific information. In this context, equipping service staff with portable IT applications can make an important difference to the speed and accuracy of decision making (Rügge, 2008). To summarize, the utility of mobile IT in the home care is as follows:

- First, the complex process of social, clinical, and medical assistance (in this case, patient care) may require access to other agencies, or technical knowledge about drugs and clinical-medical procedures.
- Second, the documentation that is needing to be produced about what is decided and done can be recorded on the spot as well as communicated to multiple parties more quickly, in more different kinds of formats with fewer translation errors.

Due to the tentative progress in collating care-relevant knowledge in the available IT applications, most emphasis has been on the second dimension that has appeared more amenable to IT processing and support. To assess

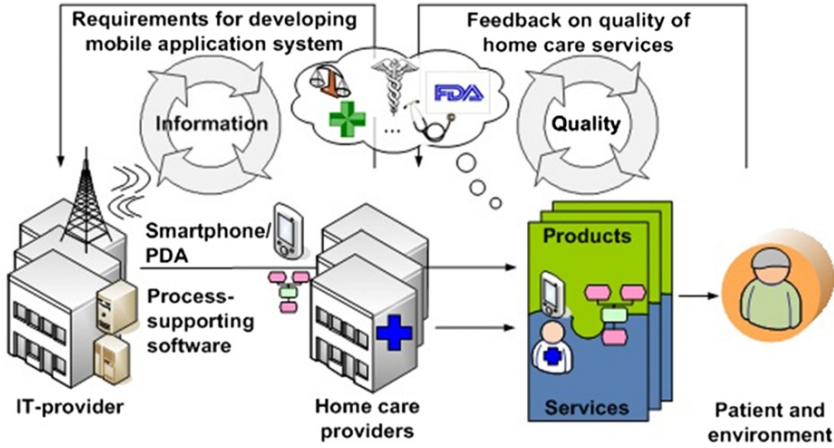


Fig. 1. Overview of Stakeholders and Sample Interdependencies (Breitschwerdt et al., 2011).

the possibility for IT to be more fully integrated into home health care, a concrete analysis must now be conducted to detect domain-specific and detailed potential benefits and negatives for all stakeholders and to evaluate the likelihood of uptake by potential users (Hannah, Ball, Edwards, Callahan Hunt, Breckenridge Sproat, & Rutherford Kitzmiller, 2006). An overview of the range of interdependencies among stakeholders is presented in Fig. 1. As the figure shows, mobile technologies may create higher degrees of connectivity, but they initiate a complex network of relationships among IT providers, health care organizations, home caregivers, patients, and the technology itself of course.

In the following sections, we offer an overview of mobile technologies in TFS to identify their potential for home care. However, first, it is necessary to define the evaluation methods applied to assess effectiveness.

Mobile health care IT functions in an environment involving distinct information processes, materials, and protocols. To analyze these settings, it is necessary to practice interdisciplinary forms of analysis. On the other hand, there are ethical and legal constraints that affect health care professionals' way of handling information. The corresponding rules and laws differ not only from country to country, but also potentially even from state to state within a country. Therefore, mobile health care IT can only be

successfully implemented if matters pertaining to existing legal systems have been addressed and solved on a local basis.

Legal Constraints: Germany and Australia

Since July 2010, Australia has a single national registration authority that specifies the registration obligations of health professionals. For example, nurses are registered through the Nursing and Midwifery Board of Australia (NMBA), an agency under the Australian Health Practitioner Regulation Agency. However, responsibility for complaints and other issues is continuing under a local state system.

Further, there are specific ethical principles that are of special relevance to a nurse in a community setting. In addition to this, there are legal aspects nurses in Australia have to attend to. The two main sources of nursing-related law are general legislation and common law. Civil and criminal laws are the most important areas for home care (Kralik & van Loon, 2011). All community health organizations are controlled by a combination of state and federal legislation. For example, the Department of Health and Ageing administers therapeutic goods, funding, and medical insurance matters.

For most nurses, professional governance will be of much more relevance than court law. For example, the NMBA as a national system is the central point for nurse registration. However, most local guidelines still refer to the Australian Nursing and Midwifery Council (Australian Nursing and Midwifery Council, 2006).

For the daily community care work, home nurses can refer to the professional nursing code of practice. The legal aspects are covered by the nurse's contract of employment and the responsibility for service provision and accounting lies with the organization of the nurse (Kralik & van Loon, 2011).

In Germany, by contrast, there are a host of laws and regulations that have to be attended to. On the one hand, there are federal laws in the Code of Social Law Sozialgesetzbuch (SGB). Especially the books V (health insurance law), XI (nursing care insurance), and XII (social welfare) are of particular interest to nurses in a community setting. Patient care outside hospitals has always priority to inpatient care (SGB XI, § 3). This simple fact is not easy to implement in a real-life setting, especially because outside hospitals the availability of expert knowledge is of special interest (Rügge, 2003).

On the other hand, several state laws affect the daily work of a nurse as well. The situation is further aggravated by the fact that these laws differ from state to state. Nurses have to adhere to different laws, depending on the state they work in. The law governing nursing (Krankenpflegegesetz, KrPflG) specifies the required skills and responsibilities for nurses working in patient care. All these regulations impact the design of mobile technologies in the home care setting.

Home Care Requirements and Processes (IT)

Home care has been described as being subject to the “uno-actu” principle (Thomas, Walter, & Loos, 2008). This principle articulates the expectation that nurses in a community setting have to have a range of skills to enable them to fulfill their work autonomously (Bamberger, König, & Pflaum, 2010). Lacking the possibility of consultation with colleague nurses, compounded by a lack of expertise, can lead to inadequate or even dangerous care (Hanson, 2011).

Home care nurses are increasingly using IT (Gilmour, Scott, & Huntington, 2008; Morris-Docker, Tod, Harrison, Wolstenholme, & Black, 2004) and handheld technologies (Brian, Brian, Hildebrandt, & Stolworthy, 2005), and yet their technological mobility is not consistently supported by their organization (Hübner & Sellemann, 2005). Systems to support outpatient care have been developed (Anderson & Aydin, 2005), but these systems privilege physicians’ practices (Aydin & Forsythe, 1997) or desktop applications like scheduling, GPS-fleet management, and resource planning (Lipinski, 2005). Others target quality assurance (Hannah et al., 2006) and scattered smartphone-based systems, including

- recording nursing services at point of care and data transfer into the central information systems as a basis for billing the insurance company and salary accounting,
- planning assignments, appointments, and routes with recording of time spent at site of caregiving and dependent modifications,
- central procurement platform for mobile ordering of medication with an implemented prescription supply chain (physician to drugstore).

Such solutions were developed and practically tested in cooperation with care institutions. However, ongoing difficulties are low user-friendliness, difficult stakeholder linkage, and low platform compatibility (Rügge, 2008).

Solutions to these challenges may be found in mobile application systems being used by German TFS in industries such as wind power, automobiles, mechanical, and plant engineering. There, notebooks or PDAs are already part of the service providers' equipment (Bernhard, König, Krupp, Pflaum, & Strauß, 2010; Thomas, Krumeich, & Fellmann, 2010) and online via mobile communication networks. Manufacturers provide field technicians with additional information concerning their service, for instance, the workflow of machine-specific maintenance or repair processes. Customer benefits are created through the combination of machine, service, documentation, process consultation, and modern IT. Such a hybrid solution makes possible more efficient service provision. In this environment, which is similar to the domain of home care, a combination of process modeling, mobile applications, and others has proved to be an innovation driver (Thomas, Walter, Loos, Nüttgens, & Schlicker, 2007).

Potentials of (Mobile) IT Solutions

In the area of home care, mobile IT solutions now exist supporting scheduling, documentation, billing, logistics, or administration, despite IT being claimed not to be able to directly support actual caregiving (Reichert et al., 2008). So far, due to the lack of technologies available, nursing support has been carried out mostly using written notes and personal memory (Rügge, 2008). Low IT integration into home care becomes also evident when we consider existing home care process maps. In a German guideline book for home care of several hundred pages, more than 130 different multistep activities are listed, for example, concerning the complex treatment of fractures or giving medicine. Enriched with illustrations, information is provided regarding indication, symptoms, preparation, execution, postprocessing, or necessary auxiliary means like medicine or bandages (Döbele, Becker, & Glück, 2006). Nearly the same content and size apply to other nations' resources in this domain, for example, English-language resources (e.g., Berg & Toussaint, 2003; Hegner, Acello, & Caldwell, 2008).

Currently, laptops are used as a portable specialist home care reference resource (Leimeister, Krömer, Kuhn, & Horsch, 2005), making it possible to retrieve illustrations and instructions at the place of service provision. Using a laptop, the autonomous service provider has access to an auxiliary knowledge base (Thomas et al., 2007), thus making printed materials obsolete.

MOBILE APPLICATION DESIGN

Requirement Analysis of Mobile Applications in a Nursing Setting

As the foregoing confirms, the scope of mobile IT research in home care, particularly targeting smart phones, appears to be limited. To articulate the standard requirements of a mobile application in the home care setting as a design science artifact (Hevner, March, Park, & Ram, 2004), a case study analysis (Darke, Shanks, & Broadbent, 1998) was conducted. This involved the extraction of relevant data from selected sources: six papers (Darke et al., 1998 recommend considering 4–10 cases) matching the criteria of describing *mobile phone solutions in nursing* from different countries including the United States (Altmann & Brady, 2005; Koeniger-Donohue, 2008; Miller et al., 2005), the United Kingdom (Laxton & Coulby, 2009), Germany (Günther, Feldner, & Schulz-Salveter, 2009), and Australia (Farrell & Rose, 2008) could be identified from a literature search. The requirements found were classified into categories (Thomas, 2006) as shown in Table 1.

With these design requirements as basis, the design of home care IT can start. For example, IT resources can be embedded into existing hardware such as smartphones, or integrated with other software systems via specialized interfaces (Breitschwerdt et al., 2011). Another approach can be adopted from the above-mentioned TFS: product-service systems (PSS). The PSS concept describes the merging of production factors, the physical product, and service-relevant information into efficient service processes. The service of a provider can be organized in a more customer-oriented and efficient manner through the use of such hybrid bundles of products and services, for example, by using documentation and state-of-the-art IT (Thomas et al., 2007). The innovative aspect of PSS applied to home care is that home health systems can integrate multiple services from solution providers, like central data management, software updates or quality assured, standardized customer-tailored nursing process representations (as illustrated in Fig. 1), and suggests feedback cycles between the stakeholders. Another example could be linking documentation to avoid media breaks and generate synergies, for instance, through automated filling of checklists during caregiving.

Such an approach might also help with applying core competencies (Bititci, Martinez, Albores, & Parung, 2004). This may result in innovation as experienced in TFS where the feedback from the recipient concerning quality and usefulness led to improvements (Thomas et al., 2007). In the

Table 1. Summary and Categorization of Requirements for Accomplishment of Identified Challenges.

Challenge	Requirement	Category
Limited readability, size of the screen	A big readable screen, however, still handy in use	Hardware Software
	Flexible optimization of the content for different (mobile) devices	
	Usability of the user interface	
Only limited memory capacity	Provision of up-to-date memory capacity	Hardware
Presentation of (different) data formats	Use of standardized data formats (open source) for exchangeability and reusability	Software
Usability of the user interface	Use of user-friendly menus (e.g., dropdown menus) instead of on-screen keyboard inputs	Software
Doubts about data security	Save personal or critical information separately and protect them effectively	Software
Software quality	Quality management of the software development	Software
	Tests with prospective users	
	Usability of the user interface	
	Default values and preconfiguration of the content and information sources	
Insufficient dial-up or speed	Offline modus	Software
	Make sync-/refresh options available automatically	
	Use of high-performance applications	
Dissatisfying battery life span and charging time	Supply up-to-date batteries and charging technologies	Hardware
High weight, limited portability	Light devices	Hardware
	Applicable in means of transportation (e.g., case or box)	
Theft-/Loss-/Damage risk	Problem-oriented awareness raising of the users	Individual Hardware
	Proper transportation possibility (e.g., case/box, robust device)	
Costs	Take purchase costs (hard-/software) and running expenses (e.g., mobile data pay scale) into account	Hardware Software Individual

Table 1. (Continued)

Challenge	Requirement	Category
Affected user motivation and acceptance	Change management arrangements, e.g., rules for use Integration in existing solutions	Individual Organization Software
Fear of innovations and concerns about the use of technology in a care setting	Change management arrangements (e.g., pro/contra analysis) Sensitization of the user toward advantages for the patients	Organization Individual
Familiarity with the use of the device before the introduction	Change management in terms of hard- and software trainings Usability of the user-specific and individually customizable user interface	Individual Organization Software
Support for the use after the introduction	Naming of contact persons (e.g., over the phone helpdesks) Offline support Online support web sites	Organization Software

context of home care, quality improvements might include the standardization of care processes (Simons et al., 2007), benefiting not only patients but also health care organizations and public authorities. Because of the cost benefits, additional stakeholders, such as physicians, may also be attracted by PSS (Sarela, Whittaker, & Korhonen, 2009). However, a practical validation of the findings here requires further empirical research involving more stakeholders and sites. This work will be targeted in our upcoming projects.

CONCLUSION

Home care faces many challenges, which can be addressed at least in part by mobile IT solutions. The most likely hardware platform is a small mobile device like a smartphone or a tablet rather than the laptop. A comprehensive evaluation is yet to be carried out to refine expectations, scenarios, and needs, and build these into relevant software applications (Harrison & Lee, 2006). Since home care providers are currently not focusing on mobile IT as suggested in our overview, it must also be

identified whether or to what extent they are willing to adopt and delegate such application systems to external providers (Altmann & Brady, 2005; Günther et al., 2009; Heß & Breitschwerdt, 2012).

Also, as for all IT matters in health care, legal aspects must be considered (Brettlecker et al., 2008) as well as the relevance of, for example, the Australian Therapeutic Goods Act of 1989 (Kralik & van Loon, 2011) and the German Act on Medical Devices' Regulations (Federal Institute for Drugs & Medical Devices, 2009). While as yet unknown factors may influence adoption (Zhang, Cocosila, & Archer, 2010), preliminary results obtained indicate the considerable potential for novel mobile application systems in home care.

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THE IMPORTANCE OF USING OPEN SOURCE TECHNOLOGIES AND COMMON STANDARDS FOR INTEROPERABILITY WITHIN eHEALTH: PERSPECTIVES FROM THE MILLENNIUM VILLAGES PROJECT

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Olivia Velez, Nadi Nina Kaonga and
Matt Berg

ABSTRACT

Purpose – The purpose of this chapter is to illustrate the importance of using open source technologies and common standards for interoperability when implementing eHealth systems, and to illustrate this through case studies, where possible.

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Design/methodology/approach – The sources used to inform this chapter draw from the implementation and evaluation of the eHealth Program in the context of the Millennium Villages Project (MVP).

Findings – As the eHealth Team was tasked to deploy an eHealth architecture, the Millennium Villages Global-Network (MVG-Net), across all 14 of the MVP sites in sub-Saharan Africa, the team not only recognized the need for standards and uniformity but also realized that context would be an important factor. Therefore, the team decided to utilize open source solutions.

Practical implications – The MVP implementation of MVG-Net provides a model for those looking to implement informatics solutions across disciplines and countries. Furthermore, there are valuable lessons learned that the eHealth community can benefit from.

Originality/value – By sharing lessons learned and developing an accessible, open source eHealth platform, we believe that we can more efficiently and rapidly achieve the health-related and collaborative Millennium Development Goals.

Keywords: eHealth; interoperability; open source; health information technology; standards; sub-Saharan Africa

INTRODUCTION

Background on the Millennium Villages Project

The Center for Global Health and Economic Development (CGHED) is a research unit at the Earth Institute at Columbia University. CGHED develops and coordinates the Earth Institute's global health programs in low- and middle-income countries, with an overall aim to enable and support countries to achieve the Millennium Development Goals (MDGs). CGHED houses the Millennium Villages Project (MVP) which is a community-led initiative that seeks to serve as a model to help and empower rural African communities out of extreme poverty and achieve the MDGs by 2015.

The MVP initiative is supported by a multidisciplinary team of researchers at Columbia University. The Columbia International eHealth

Laboratory links the Department of Biomedical Informatics at the College of Physicians and Surgeons, the Department of Epidemiology at the Mailman School of Public Health, and the CGHED at the Earth Institute to help develop innovative electronic health (eHealth) solutions for use by MVP and others around the world. MVP also involves partnerships with Millennium Promise (a non-governmental organization), the United Nations Office for Project Services, and the United Nations Development Programme to support operations and implementation of the program. The Millennium Villages constitute 14 sites in 10 sub-Saharan African countries with populations of between 5,000 and 85,000 people each in Koraro, Ethiopia; Sauri, Kenya; Dertu, Kenya; Ruhiiira, Uganda; Mayange, Rwanda; Mbola, Tanzania; Mwandama, Malawi; Gumulira, Malawi; Potou, Senegal; Tiby, Mali; Toya, Mali; Bonsaaso, Ghana; Pampaida, Nigeria; and Ikaram, Nigeria. MVP interventions are centered on five sectors: agriculture, health, education, enterprise, and infrastructure with a strong focus on empowerment of women and girls.

The eHealth Program

To support increased access to health services and information and to improve the quality of care, a broad range of information and communication technology systems have been designed, tested, deployed, and evaluated as part of the eHealth Program within MVP. Systems and initiatives that have been deployed include: (1) the Millennium Villages Global-Network (MVG-Net), which includes ChildCount+, Open Data Kit (ODK) Clinic, Open Medical Record System (OpenMRS), and other applications; (2) an upgrade of network connectivity in MVP sites through a partnership with Ericsson; (3) provision of mobile handsets for all health workers in the 14 MVP sites through a partnership with Sony Ericsson; (4) the provision of SIM cards for health workers to create a closed user group; and (5) the creation of toll-free emergency lines and toll-free short message service (SMS) numbers for ChildCount+ and other RapidSMS-based applications through partnerships with AirTel Bharti, MTN, and other mobile operators (ChildCount+; Kanter, Negin, et al., 2009; ODK; OpenMRS).

To facilitate collaboration across the different countries, languages, and governmental systems, the MVP eHealth architecture has been built using a Free/Libre Open Source Software for Health Care (FLOSS-HC) platform and has focused on the use of open and international standards, where

possible. Open source is a description of both software and the process for using and modifying the software (providing free access to source code allowing for the sense of local “ownership” by developers and programs that use it; see Table 1). The process of implementing MVG-Net across the MVP sites has highlighted numerous lessons learnt that will be invaluable to health information technology as it relates to implementation and the exchange of information across regions and nations (Kanter, Dick, et al., 2009). Therefore, the purpose of this chapter is to illustrate the importance of using open source technologies and common standards for interoperability in the context of an international eHealth project.

Table 1. The Open Source Definition (Open Source Initiative).

1. *Free Redistribution*

The license shall not restrict any party from selling or giving away the software as a component of an aggregate software distribution containing programs from several different sources. The license shall not require a royalty or other fee for such sale.

2. *Source Code*

The program must include source code, and must allow distribution in source code as well as compiled form. Where some form of a product is not distributed with source code, there must be a well-publicized means of obtaining the source code for no more than a reasonable reproduction cost preferably, downloading via the Internet without charge. The source code must be the preferred form in which a programmer would modify the program. Deliberately obfuscated source code is not allowed. Intermediate forms such as the output of a preprocessor or translator are not allowed.

3. *Derived Works*

The license must allow modifications and derived works, and must allow them to be distributed under the same terms as the license of the original software.

4. *Integrity of the Author's Source Code*

The license may restrict source code from being distributed in modified form only if the license allows the distribution of “patch files” with the source code for the purpose of modifying the program at build time. The license must explicitly permit distribution of software built from modified source code. The license may require derived works to carry a different name or version number from the original software.

5. *No Discrimination Against Persons or Groups*

The license must not discriminate against any person or group of persons.

6. *No Discrimination Against Fields of Endeavor*

The license must not restrict anyone from making use of the program in a specific field of endeavor. For example, it may not restrict the program from being used in a business, or from being used for genetic research.

7. *Distribution of License*

The rights attached to the program must apply to all to whom the program is redistributed without the need for execution of an additional license by those parties.

Table 1. (Continued)

8. License Must Not Be Specific to a Product

The rights attached to the program must not depend on the program's being part of a particular software distribution. If the program is extracted from that distribution and used or distributed within the terms of the program's license, all parties to whom the program is redistributed should have the same rights as those that are granted in conjunction with the original software distribution.

9. License Must Not Restrict Other Software

The license must not place restrictions on other software that is distributed along with the licensed software. For example, the license must not insist that all other programs distributed on the same medium must be open source software.

10. License Must Be Technology-Neutral

No provision of the license may be predicated on any individual technology or style of interface.

APPROACH

The sources used to inform this chapter draw from the implementation and evaluation of the eHealth Program in the context of the MVP. To facilitate collaboration across the different countries, languages, and governmental systems, an eHealth architecture was developed – MVG-Net. MVP took advantage of a process based on an enterprise architecture to show interrelationships between country-specific and more global requirements for information systems and between architectures and solutions (as shown in Fig. 1). This was based on work by David Lubinski that describes how country-specific requirements and existing solutions can inform a more generalizable architecture that can then lead to common platforms and tools, which then lead to country-specific technology solutions (Stansfield, Orobato, Lubinski, Uggowitz, & Mwanika, 2008). Open source tools allowed us full control over the process and permitted iterations on local requirements, creation of the general MVG-Net architecture, and then local adaptation and country-specific implementations.

Components of MVG-Net

MVG-Net (see Fig. 2) has been deployed across all 14 MVP sites. The architecture is based on open source platforms. Open source platforms were preferred over proprietary products because of cost and ease of customization. Compared to proprietary products, open source products require no license fees, can be tailored to fit the needs of the project, and have support from the

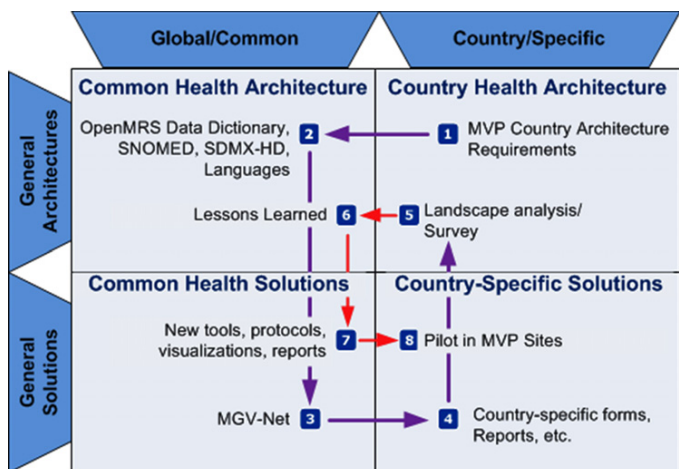


Fig. 1. Enterprise Architecture Model (Adapted from Stansfield et al., 2008).

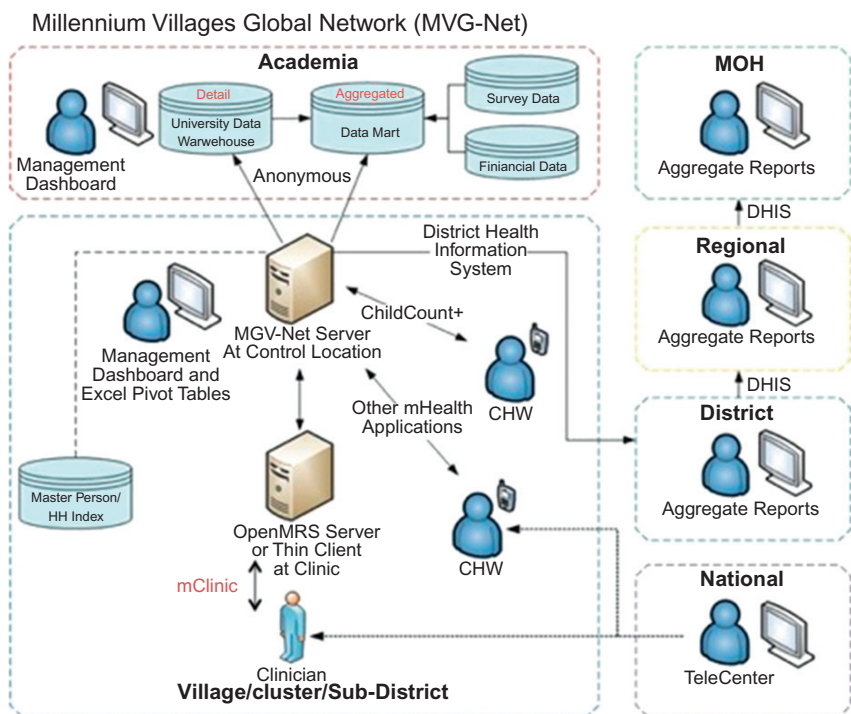


Fig. 2. Millennium Villages Global Network (MVG-Net).

development community contributing to and using the particular product. However, as with any technology – whether open source or proprietary – maintenance costs still must be considered. The following are currently components of MVG-Net: Open Medical Record System (**OpenMRS**), RapidSMS (**ChildCount+**), and Open Data Kit (**ODK**) for Android™ (mClinic). We are also in the process of integrating two other open source technologies: District Health Information System (DHIS2) and CommCare. MVG-Net takes advantage of an open source database (MySQL), interface terminology, a centralized concept dictionary (mapped to standard reference terminologies), and appropriate local technology for data entry.

OpenMRS

OpenMRS is the core of MVG-Net. It is an open source, web-based electronic medical record platform that functions as the local hub for health information collected from different sources within the Millennium Villages. It has an easily extensible data model, and can aggregate individual, person-level data collected from community health workers as well as clinic-based personnel. In MVP, the platform has been used to automate reports for the Millennium Villages Information System (MVIS) and various Ministries of Health. Currently, OpenMRS has been deployed within each MVP site to serve as the central database. It is also used to support facility-level data collection in several MVP sites where users enter and access the information from desktop computers. There is a substantial OpenMRS developer/implementer community that provides support via listserves, forums, Internet relay chat rooms, and in-person annual meetings (Seebregts et al., 2009). OpenMRS has been downloaded in nearly 50 countries, is actively deployed around the globe, and is part of national scale-up projects in Rwanda and elsewhere (OpenMRS).

ChildCount+

ChildCount+ is an SMS-based mobile phone-based community health worker point-of-care support and data collection tool built on the RapidSMS platform (RapidSMS). It is aimed at improving the health outcomes of pregnant women, newborns, and children under 5 years of age through “real-time” data collection of household-level data to trigger alerts, reminders, and health promotion messages via community health workers. The system also enables performance monitoring for more effective supervision and management of community-based health. For example, in Mayange, community health workers receive SMS notifications to conduct

follow-up visits and to remind women and children in their catchment area of upcoming clinic visits.

Open Data Kit

In the context of MVP, Open Data Kit (ODK) is currently being used for collecting data on vital events (verbal autopsy) and immunization histories of children. ODK is an open source Android™-based application that renders standard forms (XForms) on mobile devices such as smartphones and tablets. MVP uses ODK to collect data from household interviews done in the collection of verbal autopsy information for each child and maternal death occurring within an MVP site. This information is then used to inform monthly or quarterly morbidity and mortality reviews and resulting action of the health team and community to address any pressing concerns (Ohemeng-Dapaah, Pronyk, Akosah, Nemser, & Kanter, 2010). Additionally, another ODK tool, mClinic, has been developed to provide a mobile interface to link to OpenMRS. mClinic enables nurses, midwives, and other facility-based staff to enter and access electronic patient information and receive clinical decision support at the point of care. mClinic provides a mechanism for streamlining data collection for monitoring and reporting and is being used in Tanzania to collect immunization information for children under 2 years old.

Databases

OpenMRS is built on the open source MySQL database. This allows local MVP staff (and other stakeholders) secure but nonproprietary access to the data collected by MVG-Net. The data can be reported on using any SQL-compliant toolkit. Nonproprietary databases are important for allowing application owners flexibility to update their data collection tools, or move the data whenever necessary.

Interface Terminology Mapped to Reference Terminologies

One major obstacle to the adoption of health information technology is the inability of users to locate and enter information using internationally accepted clinical terminology (Kanter, Wang, Naeymi-Rad, & Safran, 2007), given their familiarity and use of locally accepted clinical terminology. To address this issue within MVP, content has been translated from English into Kinyarwanda in Rwanda; Swahili in Kenya and Tanzania; French in Mali, Senegal, and Rwanda, and Tigrinya in Ethiopia. Additional localization is occurring on an ongoing basis. The data elements are represented in the languages required at the interface using a multilingual standardized interface terminology mapped to international medical reference standards. By these

means, the data may be entered and viewed in multiple languages and it is translatable between them. The reference standards (ICD-10,¹ SNOMED CT,² RxNORM,³ LOINC,⁴ CVX⁵) allow MVP to report to international agencies, compare between MVP sites, as well as compare with other organizations working in the same domains (IHTSDO; NCIRD; Regenstrief Institute; US National Library of Medicine; WHO).

Centralized Concept Dictionary

Data collected across multiple different organizations, countries, and languages are rarely interpretable due to differences in design and modeling of the information. OpenMRS ensures that data elements are semantically understood by mapping most elements using a concept dictionary (OpenMRS Concept Dictionary). In MVP, data compatibility is achieved via standardization and mapping at the data element level. The concept dictionary is shared across all users and acts as a central repository for the definitions of all the data collected. The Columbia International eHealth Laboratory (CIEL) is responsible for maintaining the dictionary that is currently used by over 32 different organizations in as many different countries. The CIEL dictionary includes enhancements to ensure applicability in the context of primary health care across sub-Saharan Africa. Modifications can be made through the development of site-specific subsets and requests made by the OpenMRS community for new concepts to be added to the platform.

Local Technology for Data Entry

As described above, OpenMRS functions as a central hub for person-level information within the MVP sites. MVP then takes advantage of different data collection tools depending on the requirements of the users and the infrastructure in the sites. Data entry is captured both at the point of care, through ChildCount+ (standard cell phones using SMS), mClinic/ODK (smartphones using Android™), and at workstations using the web-based OpenMRS XForm interface, and retrospectively by entering data collected on paper forms using the Microsoft Infopath™ application into OpenMRS.

FINDINGS

As noted by Chan et al., “standards in data collection and reporting increase efficiency and encourage collaboration within and between organizations”

(Chan, Centiu, & Morris, 1999). The eHealth Team not only recognized the need for standards and uniformity but also realized that context would be an important factor. Therefore, the team decided to utilize open source solutions. The next section outlines the decisions and outcomes of setting up the open source eHealth Architecture in MVP.

Making the Decision to Go Open Source

As described above, there are many reasons to favor open source over proprietary software solutions. These includes cost; flexibility; ownership; and the benefit of a large, passionate, and involved developer and implementer community (Karopka, Schmuhl, Marcelo, Molin, & Wright, 2011). However, there are trade-offs that have to be taken into account:

- Resources
 - Although FLOSS applications do not require licensing fees, they do often require higher levels of developer support. Service and support may be available for free for FLOSS applications from a volunteer community, but organizations frequently must build in such support if they want to ensure reliable availability of assistance. MVP has implemented a structure that includes a separate development team and support staff. A team of three developers responds to new development requests and maintenance issues. The implementation and operation of MVG-Net is supported by an eHealth Specialist in each country. The eHealth Specialists do not develop any of the software but do help to localize it and ensure that the applications are in good working order. They also assist the MVP Health Team in acquiring the data and analyzing the results generated by the tools.
- Innovation and collaboration
 - FLOSS promotes collaboration through the reuse of code that translates to time and money savings for clients. The resultant culture of sharing and proper attribution promotes open innovation. MVP partners with other FLOSS organizations such as Dimagi in the United States, Jembi Health Systems in South Africa, Mindflow in Kenya, and Baobab Health in Malawi.
- Transparency
 - FLOSS applications are not developed as a “black box” meaning that organizations can see and modify code as necessary to ensure that it serves their purposes.

- Independence
 - FLOSS avoids vendor lock-in, reducing the risk of negative unilateral actions by the software provider.
 - FLOSS offers freedom by allowing applications to be adapted and modified locally.
- Localization/Customization
 - FLOSS applications provide a significant advantage in flexibility when customizing or localizing the software for use in different settings. In particular, many proprietary health care software solutions are designed for resource-available environments and not for resource-limited ones.
 - Localization also promotes and builds development capacity in the local software industry. This capacity is critical for ongoing support and customization that will be required over time. Since a greater proportion of the resources stay in the country, the sustainability of local support is also improved.
- Types of technologies, infrastructure
 - The OpenMRS platform was chosen for MVP due to its extensible database design and central concept dictionary. This was a key factor in providing sufficient flexibility to address each country's local data collection requirements, while still being capable of maintaining the database over time and retaining semantic interoperability of the data elements.
 - Mobile devices played a key role in overcoming the limitations of power and computer connectivity in the field. Having several different mobile solutions all linked into a central information system allowed MVP to take advantage of different infrastructure and user contexts. These mobile solutions include the use of basic/feature phones by community health workers during their household visits and the use of smartphones for verbal autopsies and point-of-care support in the clinics.
- Lessons learned
 - Developing and deploying software solutions maintained by a single organization is resource intensive and risky. Developing tools based on a common platform developed by partnering organizations allows the sharing of development (and required resources) and reduces the reliance on individual software engineers. The loss of a key developer in any software project represents a large potential risk to the ongoing sustainability of that system, especially if it is being maintained by a single or small set of organizations. Working with partners in a

collaborative manner to create the underlying platform in which tools are built helps greatly to reduce risk and costs.

Implementation and Evaluation

MVP implemented various components of MVG-Net in different sites during the pilot phase. Rapid rollout to the whole MVP network put significant strain on the team and prevented more rapid iteration of releases that would have increased acceptability of the applications. MVP has focused on four sites for a mixed methods evaluation under the Open Architectures, Standards and Information Systems for Healthcare in Africa project (OASIS II), funded by the International Development Research Centre (IDRC) in Canada. OASIS II specifically evaluates the impact of MVG-Net on qualitative and quantitative outcomes in the Millennium Village sites. The results of OASIS II should be available by mid-2012 (OASIS II-IDRC).

- Lessons learned
 - It is important to fine-tune applications and solutions in a few sites, then implement, or implement in stepwise fashion.
 - It is imperative to have adequate human resources (programmers, support staff, etc.).
 - It is not easy to set up a bridge between two information systems, and interoperability and resources are required.
 - Having development teams in multiple locations is very difficult.
 - Do not overly mix software development with implementation support.
 - Cost–benefit analyses should be incorporated into evaluations. Although keeping track of expenses is useful, it does not fully capture the potential costs or savings that result from implementation and use of eHealth tools within a health system. Where possible, work should be done with a health economist to incorporate such analyses into a monitoring and evaluation framework for eHealth projects.

PRACTICAL IMPLICATIONS

When using an open source model, there are many factors that must be taken into consideration. These include the types of applications used, the number of organizations involved, and the buy-in and capacity of stakeholders and end users to adopt the tools for their use.

With a large project like MVP, there will be many different applications used for multiple purposes, both programmatic and organizational. There is not always an open source application available for each use case, so the advantages and disadvantages of proprietary versus open source must be considered when selecting the appropriate software for each situation. In this case, an advantage for MVP is that it is a large multidisciplinary project, but under one organizational structure. Although MVP has partners in many areas, all operational matters are unified so interoperability is easier to enforce than may be true in other organizations/projects attempting similar initiatives. The MVP eHealth Team consists of several different project groups working in multiple countries under the larger heading of MVP. This means that using a common set of indicators and a centralized concept dictionary required considerable communication and coordination between the project teams.

In terms of external stakeholders, there is another set of factors to consider. Traditionally, governments provide paper books/forms to be used by health care providers to gather data at the point of care which are summarized to generate monthly reports for the relevant Ministry of Health. There is limited implementation of eHealth care platforms by governments and very few have standards for setting up such platforms. Because of the absence of standards, many projects have ended up implementing health management information systems in silos with limited consideration on interoperability. With limited health management information systems implementations in the countries with MVP sites, there is limited technical support at implementation sites. The use of FLOSS-HC with community support under the MVG-Net has leveraged community support to address technical issues that would otherwise not be possible to solve.

Overall, the MVP implementations provide a model and valuable lessons learned for those looking to implement informatics solutions across disciplines and countries due to the range of topics covered and the geographical and situational diversity in which these solutions are applied.

SOCIAL IMPLICATIONS

The MVP implementation of MVG-Net using FLOSS-HC applications and common standards provides widespread interoperability of health information systems within and between countries, regardless of their technological and economic environments. This not only reduces the cost of designing and

implementing the systems, but also the ability to share data and lessons learned between organizations and countries, which should allow for more rapid, evidence-based decision-making and program planning. Sharing what works and what does not work between countries and projects will allow us to be more efficient and more rapidly reach the goals of achieving the MDGs by 2015.

ORIGINALITY/VALUE OF CHAPTER

This chapter has highlighted numerous lessons learned that will be invaluable to health information technology as it relates to implementation and the exchange of information across regions and nations.

NOTES

1. The International Classification of Diseases – version 10 (ICD-10) is maintained by the World Health Organization (WHO) and is used for morbidity and mortality reporting globally.

2. The Systematized Nomenclature of Medicine – Clinical Terms (SNOMED CT) is an international reference terminology and ontology maintained by the International Health Terminology Standards Development Organization (IHTSDO). It is used to organize health information in a hierarchical manner.

3. RxNORM is a standardized terminology of medications and other pharmaceuticals that is maintained by the National Library of Medicine at the National Institutes of Health. It is used to organize medications into different classes and links to reference information.

4. Logical Observation Identifiers Names and Codes (LOINC) is maintained by the Regenstrief Institute. It is used to code and organize laboratory tests, results, and other observables from laboratories and medical records.

5. The National Center of Immunization and Respiratory Diseases (NCIRD) develops and maintains a list of codes for vaccines that are administered and these are known as CVX codes. An additional table of vaccine manufacturers (MDX codes) is available.

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