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Abstract:

To prepare for the 2030 "baby-boomer challenge", some governments have begun to implement healthcare reforms over the past two decades. These reforms have led healthcare information systems (HIS) to evolve into a major research area in our discipline. This research area has an increasing individual, organizational, and economic impact. Due to the 2030 "baby-boomer challenge", the number of elderly individuals continues to increase, and they may have chronic illnesses, such as eye problems and Alzheimer's disease. Given the practical need for HIS that support chronic care, we decided to conduct a literature synthesis and identify opportunities for HIS research. Specifically, we present the chronic care model and analyze how IS researchers have discussed HIS to address the needs of patients with chronic illness. Further, we identify research gaps and discuss the research topics on HIS that future work can extend and customize to support these patients. Our results stimulate and guide future research in the HIS area. This paper has the potential to strengthen the body of knowledge on HIS.

Keywords: Healthcare Information Systems, Health, Chronic Care, Literature Review, Research Opportunities.

1   Introduction

The "baby-boomer challenge" refers to challenge that national economies and healthcare systems will face by 2030 due to the aging baby-boomer population. The term baby boomers refers to people born between 1946 and 1964, and it signifies the significant increase in the birth rate after World War II. According to the United States Census Bureau, the country has 77 million baby boomers. This group contributes to a major part of this country's economy, which one can see in the fact that an economic slowdown occurred in the 2007-2009 period when the baby boomers began to retire. By 2030, the baby boomers will be 66 to 84 years old and most will have retired from work. In addition, a great proportion will have changed from commercial health-insurance plans to Medicare. This scenario will create a significant financial burden for the U.S. Government. According to the Centers for Disease Control and Prevention, people aged 66 to 84 face greater health problems, such as type 2 diabetes, heart diseases, cancer, depression, eye problems, Alzheimer's disease, arthritis and joint complications, osteoporosis, flu and pneumonia, and "sandwich generation" stress (Scripps, 2015). Therefore, governments worldwide must confront the challenge of ensuring that, in the next decade, they provide efficient healthcare information systems (HIS).

Some governments have begun to implement healthcare reforms to cope with the 2030 baby-boomer challenge. For example, in the United States, the Patient Protection and Affordable Care Act (Public Law 111-148) became law in 2010. This law expands Medicaid eligibility for people who earn up to 133 percent of the federal poverty level (FPL), subsidizes insurance premiums for people who earn up to 400 percent of the FPL (corresponding to US$88,000 for a family of four in 2010), offers incentives for firms to provide healthcare benefits to employees, forbids denying healthcare coverage and insurance claims based on pre-existing conditions, institutes health-insurance exchanges, prohibits insurers from establishing annual coverage caps, and funds medical research. In China, the National Health and Family Planning Commission (formerly the Ministry of Health) leads healthcare reform implementation to establish public health-insurance systems and improve the service quality of public healthcare providers. In urban and rural areas of China, the Chinese Government has established various public healthcare facilities, including hospitals, community health centers, and township health centers, to serve the public's healthcare needs. In Russia, Prime Minister Vladimir Putin announced a large-scale healthcare reform in 2011 and pledged to allocate more than US$10 billion in the subsequent several years to improve the country's healthcare. In Europe, Germany has launched several healthcare reforms since 1983 to support the public health insurance. Germany's total expenditure in health increased from €287 billion in 2010 to €321 billion in 2014, equivalent to approximately 11 percent of its gross domestic product in 2014. After Germany, France recorded the second-highest level of healthcare expenditure in 2014 (€237 billion) followed by the United Kingdom (€223 billion in 2014).

Such statistics demonstrate that governments worldwide face the challenge of dealing with depleting resources and rising demand for health services. Technology has contributed significantly to reducing healthcare costs and enhancing health service quality in many healthcare areas (Agarwal, Gao, DesRoches, & Jha, 2010; Kolodner, Cohn, & Friedman, 2008). The growing importance and cost of healthcare systems have contributed to HIS emerging as a vital area of research. As Wickramasinghe, Fadlalla, Geisler, and Schaffer (2005) note, HIS can address "complex challenges in trying to deliver cost-effective, high-value, accessible healthcare" (p. 294).

In this paper, we extend Wilson and Lankton's (2004) study. At the time when healthcare research started to gain IS scholars' attention, Wilson and Lankton (2004) developed a literature review on healthcare systems based on journals in other disciplines, including health informatics, medical informatics, and clinical practice. They compared the citations and impact factors for publications from IS journals with the citations and impact factors for publications from other disciplines. They highlight how IS scholars could build on the existing literature from other disciplines to develop healthcare research with a strong(er) IS flavor and offered them directions on how HIS should evolve into a global development that can yield social, organizational, and economic benefits.

Since 2004, HIS research has advanced substantially. One can see as much in the recent establishment of healthcare research centers around the world (e.g., the eHealth Research Institute at the Harbin Institute of Technology, the Health Information Systems Research Centre at University College Cork, the Enterprise Healthcare Information Systems at the University of Sydney, and the Centre for Health Informatics at the Macquarie University). IS conferences now have more healthcare tracks, and major journals now dedicate more special issues to HIS than previously. The number of publications related to

HIS has increased substantially in the past decade. Given the advancement of HIS research, we need to summarize and evaluate prior studies in this area and offer insights on research opportunities. In contrast to Wilson and Lankton (2004) who reviewed the literature on healthcare from various disciplines and for all patients, our paper focuses on HIS for patients with chronic illnesses.

We focus on HIS for chronic care because the proportion of older adults in the population continues to increase. Modernization has substantially decreased premature deaths from acute illnesses in the past several decades, which has led to people living longer. Combined with the 2030 "baby-boomer challenge", many aged people have chronic illnesses (e.g., cognitive impairment and even Alzheimer's disease). Therefore, one critical challenge that governments worldwide face in HIS involves dealing with the increased burden from patients with chronic illness. As a result, we need to investigate how to leverage HIS to ease this burden from a practical viewpoint.

This paper proceeds as follows. In Section 2, we discuss the distinction between acute and chronic illnesses and identify the seven differences between them. In Section 3, we present Wagner, Austin, and Von Korff's (1996) basic chronic care model. Then, we describe the chronic care model and extend the two models to develop the extended chronic care model. In Section 4, we review the HIS literature and identify research gaps. In Section 5, we share our perspectives on extending the current research to address the identified gaps. Finally, in Section 6, we conclude the paper.

2   Acute and Chronic Illnesses

According to the World Health Organization, the term "chronic" describes an illness that lasts for more than three months. A chronic illness can result from infections, external injuries, mental abnormalities, autoimmune defects, genetic susceptibilities, or cellular degeneration. Typical examples of chronic illnesses include Alzheimer's disease, arthritis, asthma, cancer, chronic obstructive pulmonary disease, diabetes, and some communicable diseases such as hepatitis C, the human immunodeficiency virus (HIV), and the acquired immunodeficiency syndrome (AIDS). Chronic illnesses also include certain mental disorders, such as depression, "sandwich generation" stress, and schizophrenia. The term also covers disabilities and impairments not defined as diseases, such as blindness and musculoskeletal disorders.

The term "acute illness" distinguishes such cases from chronic conditions. An acute illness features a rapid onset and lasts for a short duration. Acute illnesses include bacterial and viral infections (e.g., pink eye and strep throat) and short-acting physical symptoms (e.g., headaches, seizures, and constipation). Some acute illnesses tend to resolve rapidly on their own or with medical treatment. However, others might also be severe enough to cause death. For instance, a heart attack is a rapid-onset, short-acting health problem that health practitioners can stabilize before treating the underlying cause or it can result in death.

Because patients with acute illness and those with chronic illness show different characteristics, the objectives and scope of HIS should include customized features to support both types of patients. Based on Bodenheimer, Wagner, and Grumbach (2002), we now describe seven major differences in HIS to support patients with acute illness and with chronic illness:

1) **Treatment objectives**: acute care aims to cure patients with medication. In contrast, chronic care does not aim to cure: it focuses on promoting functional status, lessening distressing symptoms, prolonging life through secondary prevention, and enhancing quality of life.

2) **Treatment duration**: acute illnesses may resolve on their own or require short-term medical treatment. In contrast, chronic illness requires medical treatments over an extended period, and these treatments involve coordinated inputs from a wide range of health professionals and access to essential medicines and monitoring systems. Therefore, a HIS that supports patients with chronic illnesses need to connect various stakeholders.

3) **Patient empowerment**: since medical treatments for chronic illness require a prolonged period, a HIS needs to engage and empower patients in a learning healthcare system and promoting patient empowerment to reduce healthcare costs.

4) **Lifestyle change**: to confront chronic illness, healthcare practitioners often ask patients to alter their habits and maintain a regular exercise routine that promotes physical and psychological wellbeing. However, individuals cannot always easily change their habits. They face many obstacles, such as debilitating symptoms, pain, and fatigue. Some may even have limited mobility and realistic fears regarding health impediments. Therefore, HIS should help

these patients overcome their fears, promote their adherence to exercise programs, and change their lifestyles.

5) **Interconnection of patients' physical and mental health**: chronic illness may cause ongoing stress, and patients are at risk of developing depression. Depression sometimes aggravates patients' physical health conditions; for instance, depression may intensify pain and cause fatigue and sluggishness. Even worse, since people with depression find it difficult to communicate openly about their depression, if such individuals also have a chronic illness, they find interaction with others difficult. Therefore, HIS for patients with chronic illness should consider both their physical and mental health problems.

6) **Family support and family stress**: typically, a chronic illness affects not only an individual but also the individual's entire family. Such patients need the loving support of their family members to cope with their health problems successfully. Hence, all family members need to learn how they can best cope with the health problems. However, simultaneously, a family member's persistent health problems may lead to family stress. That is, chronic illness can be a family issue. In contrast to a HIS to support patients with acute illness, one needs to expand the "user" concept for a HIS that supports patients with a chronic illness to cover patients' family members.

7) **Community support**: in addition to family support, patients with chronic illness need community support. In the long term, the government should provide education and support to patients, their care givers, and family members and assist them to access appropriate health and community services.

3 The Chronic Care Model

In this section, we describe three healthcare models. In Section 3.1, we present the basic care model (for all patients). It forms the basis for the second model in Section 3.2; that is, the chronic care model (specific to patients with chronic illness). In Section 3.3, we discuss whether the chronic care model considers the aforementioned seven differences between acute and chronic illnesses and extend it to develop the third model. The second and the third models form the basis of our literature synthesis in Section 4.

3.1 The Basic Care Model

Figure 1 depicts the basic care model. This model serves as a roadmap for physicians to use to assess, plan, and implement patient care. Its main function helps physicians to develop an organized and planned approach to improve health conditions of general patients. It also outlines the best practice care and services for patients when they progress through the stages of a medical condition, injury, or event.
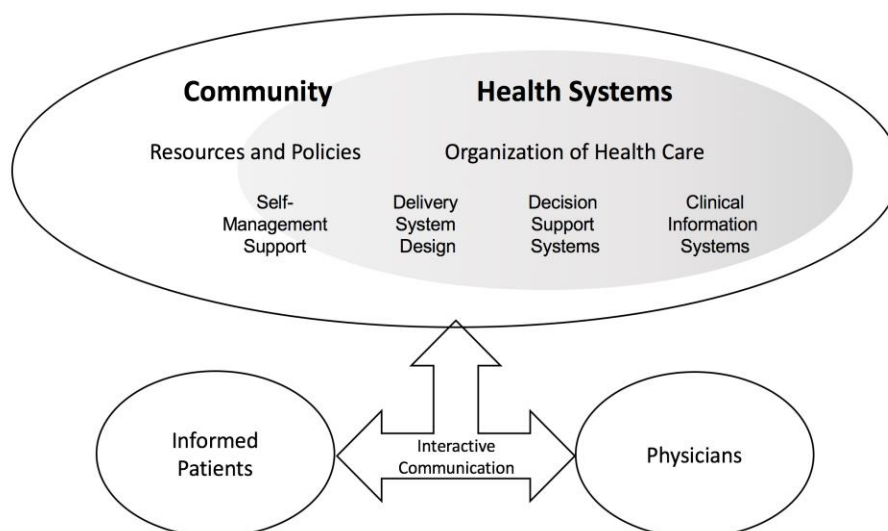

Figure 1. The Care Model

The model in Figure 1 contains a large oval that describes how patient care takes place through the community and health systems (Bodenheimer et al., 2002; Wagner et al., 1996). It also identifies four core elements of health systems: 1) a clinical IS, 2) decision support, 3) delivery system design, and 4) self-management support. Table 1 describes the four elements. These elements facilitate interactive communication between informed patients and physicians. Prior studies reveal that redesigning healthcare services using the basic care model leads to improved patient care and better health outcomes (Coleman, Austin, Brach, & Wagner, 2009; Peek, Baird, & Coleman, 2009). These studies are set in a health system context that links an appropriately organized delivery system with complementary community resources and policies.

Table 1. Core Elements in the Care Model

Element	Description
Clinical information system	It maintains a set of accessible disease-specific databases of individual patients. These databases should alert healthcare service providers to conduct required tests and provide tracking of patients' health conditions. The system should facilitate and promote information exchange between health professionals and patients.
Decision support	It develops evidence-based guidelines according to scientific evidence and patient preference and embeds these guidelines into daily practice. Health professionals should share these guidelines with patients to encourage their participation in the healthcare process.
Delivery system design	It emphasizes how care delivery services should be organized, staffed, and delivered.
Self-management support	It emphasizes the patients' role in managing their health conditions in the healthcare process. It proposes self-management techniques, such as mutual goal setting and action planning. It also outlines various methods of self-management support, such as group classes, patient skill development, and various lifestyle behaviors.

3.2   The Chronic Care Model

Barr et al. (2003) shift patient care's focus from an acute, episodic health system to a system that effective chronic care requires. They draw on Bodenheimer et al., (2002), Rothman and Wagner (2003), Wagner et al. (1996), and Wagner et al. (2001) to customize the basic care model for patients with chronic illness. Hereafter, we refer to Barr et al.'s (2003) new model as the chronic care model. Figure 2 depicts this model.
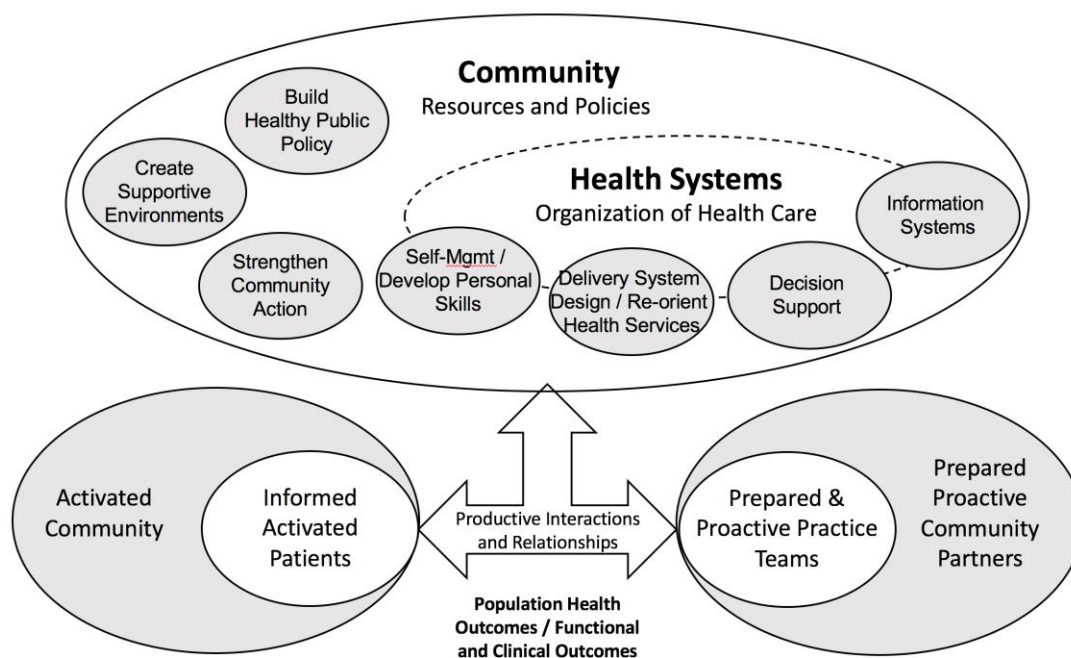

Figure 2. The Chronic Care Model

In comparing Figure 1 and Figure 2, we identify four major adaptations from the basic care model to the chronic care model:

1) **Emphasizing the role of community support**: unlike the basic care model that considers the roles of healthcare support and community support equally important, the chronic care model emphasizes community support to patients with chronic illness.

2) **Adding new essential elements of chronic disease care**: the basic care model comprises four elements (see Table 1). The chronic care model includes three additional elements: 1) build healthy public policy, 2) create supportive environments, and 3) strengthen community action. These additional elements extend the role of community support to patients with chronic illness.

3) **Activating the role of patients**: the basic care model proposes to maintain interactive communication between patients and physicians. In contrast, the chronic care model argues that patients' health outcomes will improve only on reconfiguring healthcare systems to address the specific needs and concerns of patients with chronic illness by adopting a proactive, patient-centered, and evidence-based communication style.

4) **Extending the practice teams from only physicians to teams of prepared and proactive healthcare practitioners**: the chronic care model promotes a shift from care that physicians mainly deliver to one that encourages care delivered through practice teams. Each member in a practice team brings unique value and required expertise to the patient.

3.3 Our Extended Chronic Care Model

In Section 2, we identify the seven differences in healthcare services that support patients with acute illnesses and those with chronic illnesses: 1) treatment objectives, 2) treatment duration, 3) patient empowerment, 4) lifestyle change of patients with chronic illness, 5) interconnection of patients' physical and mental health, 6) family support and family stress, and 7) community support.

In our assessment, the chronic care model in Figure 2 considers the first, second, third, and seventh features. To elaborate, the chronic care model considers the differences in the nature of acute vs. chronic illnesses; (i.e., the first (treatment objectives) and second (treatment duration) features). The model also activates the patients' role from "informed patients" to "informed activated" patients. In other words, the chronic care model suggests that patients should be more engaged and take an active role in healthcare services. It reflects the importance of the third feature (patient empowerment). Further, the extended size of "community" in the large oval at the top of Figure 2 and the three additional elements evidences that the chronic care model considers the seventh feature (community support).

However, the chronic care model says nothing about the fourth feature, fifth, and sixth features. Based on the chronic care model, we developed an extended model as Figure 3 depicts. The extended model specifies the importance of family support and the expected healthcare outcomes in relation to physical health, mental health, and lifestyle improvement.
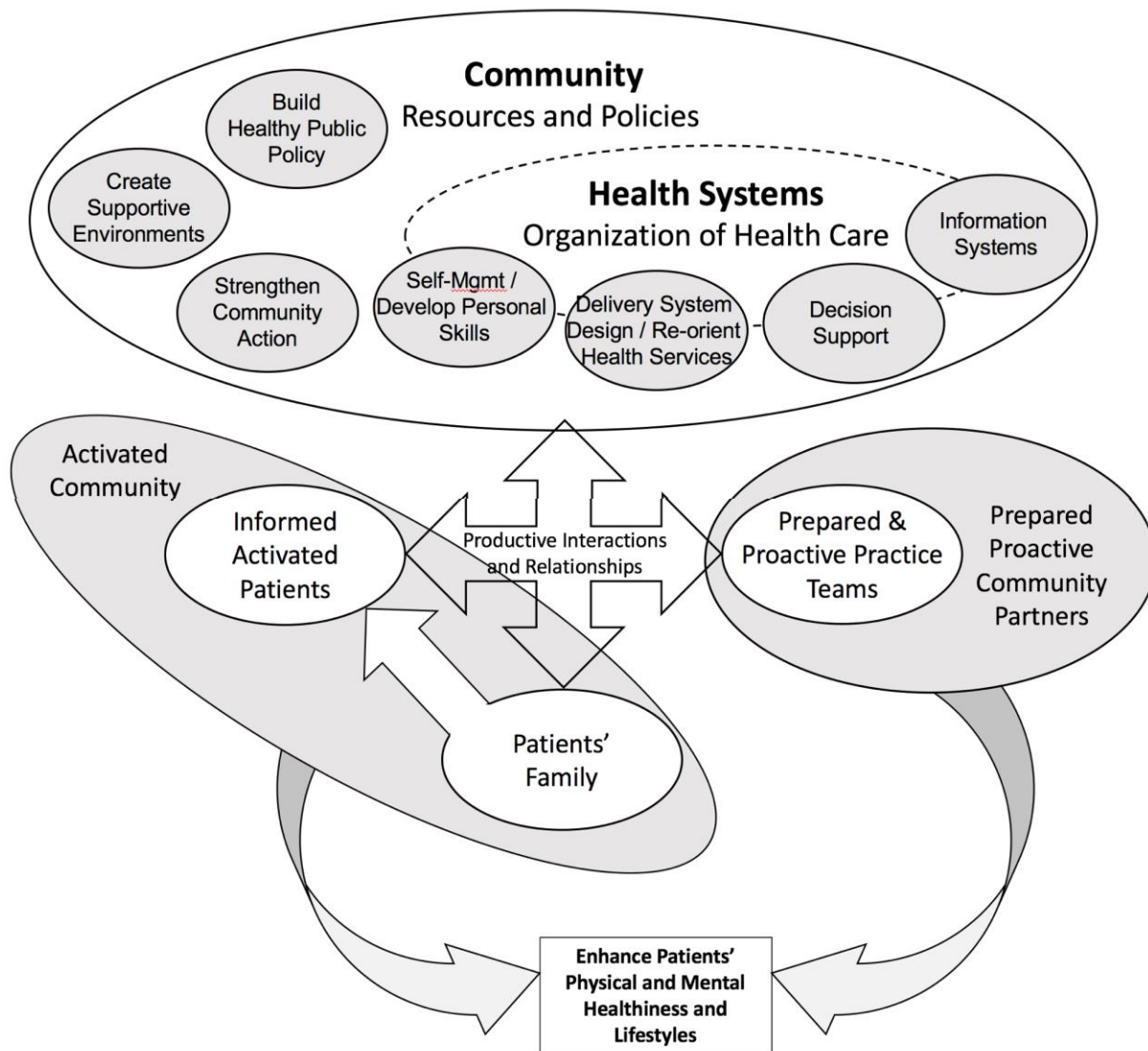
Figure 3. The Extended Chronic Care Model

4   Literature Review

In this section, we review the literature on HIS. We focus on the publications in IS journals even though healthcare research is interdisciplinary (Agarwal et al., 2010; Oborn, Barrett, & Davidson, 2011; Payton, Paré, LeRouge, & Reddy, 2011; Wilson & Lankton, 2004). We adopted this approach to help readers understand the socio-technological and technological aspects of healthcare that IS scholars study.

Further, we focus on the literature on HIS that support patients with chronic illness. We have divided the literature review into two sections: in Section 4.1, we review the HIS literature that uses "chronic illness" as the theme, and, in Section 4.2, we review the HIS literature that does not use this theme but offers findings related to some concepts in the chronic care model (Figure 2) and/or the extended chronic care model (Figure 3). To increase the readability of our review, in Section 4.2, we divide our discussion into five sections (Sections 4.2.1 to 4.2.5) that correspond to Figure 3 and then indicate research gaps in Section 4.6.

4.1   Focus of the IS Literature regarding Chronic Illness

In our literature search, we identified few publications in the past decade have focused on chronic care. In this section, we present five publications from the major IS journals. These publications cover a wide

range of topics. Given the small number of publications, they do not comprehensively discuss how HIS can support patients with chronic illness, which means the topic warrants further scrutiny.

Lin, Chen, Brown, Li, and Yang (2017) adopted a design-science paradigm and used Bayesian multitask learning (BMTL) to predict risk profiling in chronic care. Given that patients with chronic illness often face multiple adverse health events over time, data analytics of accumulated electronic health records can generate precise patient risk profiling. Accordingly, the authors extended existing risk models of one specific event to predict multiple healthcare outcomes. Their BMTL approach models an arbitrary number of events concurrently and allows healthcare providers to achieve multifaceted risk profiling. Based on experimental evaluations, the authors demonstrated that their BMTL approach attains an improved predictive performance when compared with approaches that model consecutive events separately. Their study has contributed to reducing failures and delays in preventive healthcare interventions.

Delen, Oztekin, and Tomak (2012) adopted a big data-analytics approach to predict the surgical outcome for a patient undergoing a coronary artery bypass grafting. They used large, feature-rich, nationwide inpatient databases along with four popular machine-learning techniques to develop predictive models (e.g., decision trees and neural networks) and tested the developed models with an information fusion-based sensitivity analysis of these models. Their study has contributed to predicting the outcome of coronary artery bypass grafting accurately and to understanding complex medical interventions in detail.

Kelley, Chiasson, Downey, and Pacaud (2011) adopted a behavioral approach to examine how HIS helps patients newly diagnosed with type 2 diabetes with their self-care activities. The healthcare system development comprises two phases: 1) the precede phase in which one develops a plan of action through these pathways and 2) the proceed phase in which one implements educational interventions. The authors recruited patients newly diagnosed with type 2 diabetes to use the system for one year to gain an understanding of how healthcare systems could help them improve their health outcomes and routinize their self-care activities.

Combes and Azema (2013) used data analytics to analyze behavioral patterns related to autonomy and disability levels of elderly people living in nursing homes. The autonomy-disability level corresponds to elderly people's ability to perform activities of daily living, such as dressing and moving. The authors collaborated with a health organization in France to collect data of four nursing homes in Saint-Étienne city. Developing a new clustering approach based on principal component analysis, they analyzed 2,000 observations of dependence evaluations corresponding to approximately 600 residents. They identified groups of residents with similar behavioral patterns in nursing homes to help tailor services to the needs of these residents.

Dadgar and Joshi (2018) examined how one can use HIS to help patients with diabetes to self-manage their health at home. The authors identified a set of values (e.g., autonomy, dignity, and hope) that patients with diabetes expect HIS to have and suggest design-science principles to guide future redevelopment of self-management HIS. Although only a few publications have focused on HIS for chronic care, academics have not neglected it. Indeed, a special issue of *MIS Quarterly* called "The Role of Information Systems and Analytics in Chronic Disease Prevention and Management", which will appear in 2019, underscores its importance.

4.2   General HIS Research Relevant to Chronic Illness

Some IS publications have focused on general HIS development and have not used "chronic illness" as the theme; however, their findings pertain to HIS for chronic care. We followed the structure of Figure 3 to divide our discussion into five parts: 1) health systems (corresponds to the inner circle of the upper oval), 2) community (corresponds to the rest of the upper oval), 3) activated community (corresponds to the bottom-left oval), 4) prepared and practice teams (corresponds to the bottom-right oval), and 5) patients' physical and mental health and lifestyle (corresponds to the bottom rectangle).

Notably, both the chronic care model (Figure 2) and the extended model (Figure 3) have adopted an organizational perspective to guide (in a primary care setting) the entire healthcare development for patients with chronic illness. The healthcare development focuses on creating practical, supportive, evidence-based interactions between informed, activated patients and proactive practice teams. Since the need for services (and not the need for technology) initiated the two models, they do not focus on technology. Therefore, some components in the two models do not relate to technology development, and we do not expect IS scholars to conduct research projects to cover every single healthcare component in the two models.

4.2.1 Part One: Health Systems—Organization of Healthcare

This part covers the development of healthcare modules with the explicit intention to improve their functional performance. IS scholars have expended substantial efforts to develop various healthcare modules. Most healthcare modules pertain to all patient types (including patients with chronic illness); hence, we believe their findings align with the chronic care model.

Examples of the HIS modules include decision support for evidence-based medicine (van Valkenhoef, Tervonen, Zwinkels, de Brock, & Hillege, 2013), home-care services (Benzarti, Sahin, & Dallery, 2013), scheduling and appointing modules (Cordier & Riane, 2013; Meskens, Duvivier, & Hanset, 2013), spatial healthcare accessibility (Li, Vo, Randhawa, & Fick, 2017), and intelligent systems for food and health risks (Yoo, Parameswaran, & Kishore, 2015).

Some IS scholars have examined the managerial challenges in developing and implementing IS in addition to how IS algorithms are developed, application interfaces, and systems. For example, Rivard, Lapointe, and Kappos (2011) examined how culture affects the difficulty level of clinical IS implementation. A large body of research has considered healthcare patients' and physicians' IS adoption (e.g., Hung, Tsai, & Chuang, 2014; Sherer, Meyerhoefer, & Peng, 2016; Spaulding, Furukawa, Raghu, & Vinze, 2013; Tong, Tan, & Teo, 2017; Venkatesh, Zhang, & Sykes, 2011; Yang, Kankanhalli, Ng, & Lim, 2013, 2015; Yaraghi, Du, Sharman, Gopal, & Ramesh, 2014). Remarkably, in 2013, the journal *Decision Support Systems* published two special issues: "Analytics and Modeling for Better Health Care" and "Decision Making in Healthcare". These issues contain 21 publications (in total) on health system development and design.

4.2.2 Part Two: Community—Resources and Policies

This part covers resource allocation and policy making in relation to the healthcare community outside clinical interactions between patients and physicians. It focuses on social, organizational, and economic issues. Related topics include (but are not limited to) developing community policies, dealing with a healthcare support paradigm shift, managing the political environment, aligning sectoral policies for health, effectively using healthcare personnel, and supporting healthcare professionals (Grover & Joshi, 2015).

Healthcare policies and technology design are intertwined. In a recent publication, Cousins (2016) focused on the legal issues the healthcare community faces. The author reviewed three important healthcare acts (the American Recovery and Reinvestment Act of 2009, the Health Information Technology for Economic and Clinical Health Act of 2009, and the Health Insurance Portability and Accountability Act of 1996) and discussed the related implications for confidentiality and security of electronic health records, meaningful use of HIS, health-information exchange, and information governance from a legal perspective.

The Health Insurance Portability and Accountability Act states that privacy and data-security risks discourage healthcare organizations from releasing their medical data. Thus, data sharing and integration in healthcare has become a challenge. Inspired by this act, IS scholars have developed systems to support secure data sharing and protect data privacy. Wimmer, Yoon, and Sugumaran (2016) proposed a multiagent architecture to facilitate data integration and data sharing while preserving privacy in healthcare. They investigated the problems caused by differences in data syntax, semantic heterogeneity, and diverse privacy requirements across hospitals. In addition, Angst and Agarwal (2009), Angst, Agarwal, Gao, Khuntia, and McCullough (2014), and Angst, Block, D'Arcy, and Kelley (2017) investigated IT security investment in the healthcare industry and voluntary information disclosure by hospitals.

IS scholars have examined resource allocation and policy making for hospitals and firms in the healthcare industry. Kohli, Devaraj, and Ow (2012) examined non-publicly traded hospitals and found that HIS investment in these hospitals exerts influence on firm value. Shynkevich, McGinnity, Coleman, and Belatreche (2016) used machine-learning techniques to text mine news articles and forecast movements of healthcare stock prices. Wu, Li, Cheng, and Lin (2016) developed a game-theory model to study competition in the healthcare wearable-technology market and suggested that firms investing in big data analytics will likely achieve high profits.

4.2.3 Part Three: Activated Community

This part focuses on the engagement of service consumers. In the chronic care model (Figure 2), Barr et al. (2003) considered only patients. The services that this part covers include (but are not limited to)

developing and providing facilities for patient safety, preventing health problems, monitoring patients remotely, supporting patients in social communities, identifying patient-specific concerns related to the transition process, and facilitating patients' self-management and health literacy (Grover & Joshi, 2015). In our extended model (Figure 3), we consider patients and their families. We expect healthcare services to support patients and their families in social communities and to identify their specific concerns in relation to the transition process after diagnosis or after discharge from hospital.

Two technologies particularly pertain to building an activated community for patients: 1) online health communities (OHCs) and 2) mobile health (mHealth) technology to support remote patient monitoring. Patients share their knowledge through OHCs. This sharing fulfills their cognitive and emotional needs for health information (Guo, Guo, Fang, & Vogel, 2017; Yan & Tan, 2014, 2017; Yan, Wang, Chen, & Zhang, 2016). IS scholars have explored how patients' engagement in OHCs can promote their physical health conditions (Yan et al., 2016) and mental health (Yan & Tan, 2014). Goh, Gao, and Agarwal (2016) examined the social value of OHCs for patients in urban and rural regions. They found that OHCs create social value by addressing rural versus urban health disparities through improved health capabilities and that, interestingly, urban users are often net suppliers of social support, while rural participants are often net recipients.

mHealth enables patients to track their health conditions and healthcare professionals to access medical information instantly and ubiquitously (Akter, D'Ambra, & Ray 2013). It also generates health-alert messages for patients and healthcare professionals (Varshney, 2014a). mHealth supports patients' routine health checks, mobile communication with physicians, information access to medical records, and mobile documentation for physicians (Chatterjee, Chakraborty, Sarker, Sarker, & Lau, 2009; Maass & Varshney, 2012). Given that many existing patient-monitoring applications suffer from unpredictable network coverage and unpredictable communication reliability, Sneha and Varshney (2013) developed a framework for patient-to-healthcare-professional communication to enable comprehensive patient monitoring via an ad hoc mobile network for increasing communication reliability. For a commentary on mHealth studies, see Varshney (2014b).

4.2.4 Part Four: Prepared and Practice Teams

This part focuses on healthcare practice teams. These teams include physicians, health-organization administration and staff, research-institution staff and leaders, members of medical associations, government agencies, private-sector vendors, standards agencies, non-profit-making healthcare organizations, and tax payers (Agarwal et al., 2010; Payton et al., 2011). IS scholars have proposed and developed technology to support these teams.

As we mention in Section 4.2.3, mHealth enables healthcare practice teams to communicate effectively with patients. IS scholars develop systems other than mHealth to support nurses' and doctors' daily work. For example, Singh, Mathiassen, Stachura, and Astapova (2011) developed home healthcare to implement remote patient monitoring to streamline nursing practices. Corchado, Bajo, de Paz, and Tapia (2008) developed an autonomous deliberative case-based planner agent—Autonomous aGent for monitoring ALZheimer patients (AGALZ)—for monitoring Alzheimer patients' healthcare in execution time in geriatric residences. AGALZ arranged nurses' work timetables adaptively to monitor standard working reports on their activities. Hung, Tsai, and Chuang (2014) examined nurses' intention to use HIS. Given that nurses work in a team, the authors found coworkers' perspectives on HIS to affect their intention to use HIS. Venkatesh et al. (2011) examined the longitudinal system that medical doctors use. They focused on how an individual's network position in a healthcare system influences the quality of care and, subsequently, patient satisfaction.

Hospitals use social media to support practice teams. For instance, Miller and Tucker (2013) examined the management of hospitals' Facebook pages. Using the list that the American Hospital Association provided, they identified 5,000 hospitals in the United States. Using data on hospitals' active management of their Facebook page, the authors found that a hospital's Facebook presence may promote hospital-employee sharing and employee motivation, recruitment, and retention.

4.2.5 Part Five: Patients' Physical and Mental Health and Their Lifestyle

Since health refers to both body and mind, which corresponds to physical health and mental health, this part examines whether and how patients can continue to maintain their physical and mental health

through engaging with the health development process after diagnosis and, possibly, through lifestyle improvement.

To our knowledge, most prior studies on HIS have focused on physical health. One line of research has examined how to develop self-management devices that enable patients to track their physical health. For instance, Yang et al. (2015) developed monitoring systems to record vital signs, such as blood pressure, pulse, temperature, electrocardiogram, oxygen saturation, and respiration rate. Dadger and Joshi (2018) proposed a value-sensitive design to develop a self-management system for patients with diabetes to monitor their physical health. Further, some prior studies have investigated how HIS adoption affects physical health outcomes, such as reduction in infant mortality (Venkatesh, Rai, Sykes, & Aljafari, 2016), in patient readmission rate (Bardhan, Oh, Zheng & Kirksey, 2015), in hospital stay, and in out-of-hospital morbidity and mortality (Singh et al., 2011).

Relatively few studies have explored whether HIS provide emotional support to patients. As an exception, Yan and Tan (2014) examined whether the social support exchanged in OHCs benefits patients' mental health. The authors identified three dimensions of social support—information, emotional, and companionship—and investigated their effects on how patients' health conditions evolve. They found that, through learning from other patients in OHCs, patients engage more effectively than otherwise in their disease self-management process. They also found that emotional support plays the most significant role in helping patients become healthier.

4.3   Research Gaps

As we note above, the potential of information technology development in the healthcare sector continues to increase. One can view these developments as evidencing the growing complexity of healthcare processes to support patients with chronic illness. These developments have begun to profoundly influence the way that healthcare practitioners deliver healthcare and to promote a changing balance between evidence and intuition in hospital and clinical practice. Based on Section 4.2, we identified research gaps in the IS literature and present them in Table 2.

Table 1. Topics that IS Scholars Have Examined and Research Gaps

What has been examined?	Research Gaps
Part 1: health systems—organization of healthcare	
• Proposed, designed, developed, and implemented HIS modules for clinical and hospital use • Examined factors that affect the behavioral intention of HIS by patients, doctors and nurses	1) Most technologies merely support hospital and clinical practice for healthcare professionals. 2) Few studies have examined whether healthcare technology modules developed for patients with acute illness work equally well for patients with chronic illness. 3) Scant research has examined whether the developed healthcare modules are scalable and portable; hence, the outcomes for large-scale healthcare module implementation remain uncertain.
Part 2: community—resource and policies	
• Examined healthcare resource allocation and policy making at the strategic level and proposed information technology solutions • Developed and used healthcare technologies to cut operational and administrative costs and maximize resource allocation • Developed secure data sharing and electronic health recording in response to healthcare acts	4) Limited research proposes technology-related policies for the healthcare sector. 5) A big data analytics approach to enable healthcare professionals to efficiently allocate resources is lacking.

Table 1. Topics that IS Scholars Have Examined and Research Gaps

Part 3: activated community	
• Helped patients and physicians engage in the community through OHCs and mHealth	6) Scant research has explored technologies, other than OHC and mHealth, to activate the community. 7) Few studies have explored health literacy and commented on how to activate the community when most patients have low capacity to obtain, process, and understand basic health information and services they need to make appropriate health decisions. 8) Limited research has explored how to promote engagement of patients' families in the community and information exchange and how family engagement affects patients' health conditions.
Part 4: prepared and practice teams	
• Examined how OHC and mHealth facilitate information exchange among health professionals	9) Extant research has paid little attention to healthcare stakeholders other than patients, doctors, and nurses. 10) Scant research has proposed new technologies to facilitate information exchange among health professionals to help those in rural areas. 11) Limited research has developed predictive models to prepare practice teams for identifying possible health risks.
Part 5: patients' physical and mental health and their lifestyle	
• Developed HIS to empower patients to self-manage physical health • Examined how HIS promote patients' physical health	12) Scant research has examined the longitudinal change of patients' health conditions when using a HIS or self-management device. 13) Scant research has examined whether HIS improve patients' mental health and alter their lifestyle in the long term. 14) Patients with chronic illness and their families may have depression. Few studies have examined how HIS can help to minimize, detect, and cope with depression.

5 Future Research Directions

The research gaps in Table 2 present the vital points of current knowledge on HIS supporting patients with chronic illness. In the following sections, we propose future research directions on HIS to complement and further the existing research. For readability, we map the numbering of gaps to the numbers in the right hand column in Table 2.

5.1 Health Systems: Organization of Healthcare

5.1.1 Gap 1: HIS Design and Development

Currently, many HIS still need human intervention; for instance, they do not fully automate data transfer from one system to another. We need more research that develops new healthcare modules to fill in the missing pieces along the workflow of clinical and/or hospital services from new patient pre-appointment referrals to after-service healthcare. The top oval in Figure 3 lists some important HIS modules that call for such effort. The self-management module represents one model that deserves our attention. Since chronic illness persists for a long period or otherwise has long-lasting effects, empowering patients to self-manage their health conditions constitutes a cost-effective method. In other words, focusing on patients with chronic illness will shift the traditional HIS research focus from services that simply respond to patients' demand to enabling patients to proactively seek health improvement. According to Figure 3, "self-management" has two parts: 1) self-manage health conditions and 2) develop personal management skills. Thus far, IS scholars have explored how to use mHealth to enable patients' self-management. However, little research has examined how to design and develop HIS to help patients learn and enhance their skills. To exploit the full potential of self-management systems, healthcare professionals must educate patients regarding understanding their health conditions, the proper ways to use self-management tools, and the need to closely follow physicians' guidelines to track their health conditions. Research could explore technologies such as connected health systems to further empower patients.

5.1.2   Gap 2: Extend Healthcare Modules for Acute Illness to Chronic Illness

In Section 2, we describe the key differences in care services for patients with acute illness and patients with chronic illness. The classification of chronic illness is still coarse. Each chronic illness differs. Patients with chronic illness vary in terms of functional mobility, chronic pain, and memory deficit. For instance, patients with cancer often have physical pain and depression, but patients with Alzheimer's disease do not. Thus, both groups have different needs as do their family members. Further, even if patients have the same chronic illness, a chronic illness triggers different information and emotional needs at different phases. For instance, patients in the pre-diabetes stage and patients with diabetes have different information and emotional needs. Although we believe that different HIS have a similar technology development in their backend to support hospitals and clinical patients, each HIS needs personalized features to fit the information about and emotional needs of each type of patient with a chronic illness. This requirement leads to research opportunities to examine personalized design features of HIS for these patients.

5.1.3   Gap 3: Examine the Scalability and Integration of HIS Modules

Studies have often proposed modules and algorithms for one functional unit in the healthcare process (e.g., patient appointment schedules and medical inventory ordering). These studies have applied and tested the developed modules and algorithms in restricted settings, such as in one single clinic or hospital. In the long term, if all healthcare systems connect and integrate with one another, governments will benefit from the resulting increase in cost effectiveness and efficiency (in terms of information sharing). Technical design poses one key issue that IS developers should investigate. In addition to technical design issues, integrating disconnected systems may lead to political and institutional problems for HIS developers. The political influence to drive the integration may be unevenly distributed. More research needs to examine how to integrate HIS on a wider scale and how to shape social beliefs and health practices more effectively to align different healthcare stakeholders' expectations.

Most studies have examined HIS in developed countries. Notably, many developing countries (e.g., Vietnam, Colombia, Mexico, Thailand, Kenya, Ghana, and Zambia) have begun to reform their healthcare systems. Developed and developing countries face different challenges in implementing HIS; thus, research needs to consider the costs and benefits of implementing healthcare systems for developed and developing countries separately. Developing countries have less established infrastructure and a less educated population. More importantly, people in developing countries often have a different mindset in relation to health, which may affect their reliance on HIS. Therefore, researchers need to customize theories on HIS technology research problems for the specific context of developing countries. For example, organizational culture, politics, management style, healthcare staff knowledge barriers, and patient mindset constitute variables that differentiate HIS technology use in developed and developing countries. Given that Africa ranks second on the list of most populated continents and that many African countries have the lowest ratios of doctors to population worldwide, HIS research specific to the country circumstances will likely have high practical impact.

5.2   Community: Resource and Policies

5.2.1   Gap 4: Develop Healthcare-oriented IS Policies

IS scholars have discussed the implications of healthcare acts on privacy issues in relation to electronic health records. They have also proposed infrastructures for secure transmission and data exchange (Baird, Davidson, & Mathiassen, 2017; Kohli & Tan, 2016; Kwon & Johnson, 2013, 2014; Yaraghi et al., 2014). However, these well-designed infrastructures cannot completely eliminate data misuse due to human intervention. For instance, in March, 2011, HealthNet announced a privacy breach for two million of its insurance customers, which exposed their names, addresses, Social Security numbers, and health and financial data. The data lacked encryption and stored on hard drives that went missing from its contractor's (i.e., IBM's) data center. This case is not a technological problem but a management issue. Therefore, an important research area for IS scholars involves proposing healthcare-related IS policies—a set of guiding principles to help healthcare professionals make decisions. One starting point involves exploring how the data privacy policy has developed in Europe. The General Data Protection Regulation (GDPR) came into force in the European Union (EU) since 25 May, 2018 (Ashford, 2018; Yu, 2018). The GDPR seeks to protect individual personal information and applies to all organizations that deal with data about E.U. citizens (Ashford, 2018; Yu, 2018). Although GDPR represents a big step toward privacy

protection, it remains inadequate. Currently, many organizations have developed artificial intelligence algorithms to analyze people's health conditions based on their behaviors on social media and mobile apps, but the GDPR does not challenge these algorithms. Indeed, intellectual property rights protect these algorithms (Ashford, 2018; Yu, 2018). What constitutes ethical use of healthcare data remains a controversy. IS scholars can contribute their opinions to this topic and propose HIS policies to guide ethical use of healthcare data.

5.2.2   Gap 5: Use Big Data Analytics to Efficiently Allocate Resources

According to Sahay (2016, p. 420):

> [W]hen it comes to "big data" and the digital future, we are at the very beginning. Despite the rapid pace of connection and the oceans of data it generates, our societies have yet to determine how all this will be used, to what purpose, and who decides.

Big data analytics for healthcare can provide value-based, patient-centric services and reduce financial waste, abuse, and fraud. One can source big data from five healthcare areas: 1) insurance claims and payment data, 2) pharmaceutical and research and development data, 3) clinical data and electronic medical records, 4) patient behavior and sentiment data collected from OHCs and social networks, and 5) smart devices and interconnected sensors, which capture people's daily activities. Data are available, but we are not ready for the big data era. Big data offers research opportunities to IS scholars. For instance, they can run pre-adjudication fraud analyses on hospital claim requests to reduce fraud, waste, and abuse. They can analyze patient profiles (e.g., segmentation and predictive modeling) to identify individuals who would benefit from proactive care or lifestyle changes to extract knowledge related to preventive care.

5.3   Activated Community

5.3.1   Gap 6: Develop Technologies to Activate Community

The degree of professional and patient involvement in care is changing in terms of balance. Given that external sources (e.g., mass media) impart health information to patients, when patients come from a less deferential society, they may be less willing to accept physicians' instructions without explanations. An activated community seeks to increase patient and family engagement in healthcare processes. In doing so, this community should enable three types of (bidirectional and proactive) patient-centric communication: 1) patient-to-patient, 2) patient-and-physician, and 3) patient family-and-physician.

Certainly, OHC and mHealth support asynchronous and synchronous communications in addition to textual, audio, and video content sharing. They have high media richness. With the evolution of handheld devices and social networks, IS scholars will likely innovate technology to support the three patient-centric communication types. The next question concerns how to motivate patients, their families, and physicians to contribute to the activated community. IS scholars can explore how to protect user privacy on open platforms so that patients (or their families) can converse about sensitive health issues. In addition, the low physician to patient ratio contributes to designing a health-related knowledge base, building personalized health agents that handle simple questions from patients and from their families, and developing textual mining algorithms to process questions and forward them to physicians with relevant expertise.

5.3.2   Gap 7: Develop Technology to Support Patients with Low Health Literacy

Low health literacy poses a barrier to effective patient care. To address this issue, the general principle involves enabling health professionals to identify patients with low health literacy and understand each patient's health literacy skills and language barriers and to educate and counsel these patients. At present, many elderly patients find handheld devices, such as mHealth, difficult to use. As a result, these patients compensate for their low literacy skills by using external information resources (Birru et al., 2004), which makes healthcare services inefficient. In the future, IS scholars can engage patients and health professionals in information technology skills building and design and develop assistive technology. User friendliness represents a key issue of assistive technology. Improved interface design with voice control and visualization functions can serve as one design and development direction. In addition to interface design, IS scholars can customize communication styles, advice, counseling, and information and emotional support to these patients' needs.

5.3.3   Gap 8: Engage Patients' Families in Activated Community

Families' psychological closeness with patients mostly drives efforts to engage with patients' families in the activated community. Technology can help to promote their engagement, but it cannot alter bad existing relationships among family members. Assuming that a patient's family plans to participate in the healthcare process with the patient, what can technology achieve? Answers to this question hinge on the role the family plays in the healthcare process. Some families help patients with low health literacy to understand healthcare information. Some help patients to manage physical disability. Others provide emotional support to patients. IS scholars should first understand the ways in which patients' families can contribute to healthcare processes. IS scholars need to identify possible threats as well. For instance, assume that a family member comprehends healthcare information and presents it to a patient with low health literacy, which increases how much the patient depends on the family member and may impede direct communication between the patient and physicians. IS scholars can innovate technology to support patients' families in terms of facilitating communication with patients and physicians; enabling them to assist patients in self-management; strengthening the trust relationship among patients, their families, and physicians; and providing emotional support to patients. A partnership between a patient, the patient's family, and other healthcare personnel can help healthcare personnel adopt a patient-centered approach to optimize health outcomes.

5.4   Prepared and Practice Teams

5.4.1   Gap 9: Support Other Healthcare Service Providers

The balance between hospitals and alternative care settings is changing. Hospitals have the advantage of confining the patient in one place and waiting for healthcare personnel to investigate or conduct treatments. Organizationally, delivering complex packages of care then becomes easy, but a hospital may not be the most appropriate setting for patients with chronic illness. For instance, patients with moderate disabilities may be able to manage better in their own homes but with enhanced nursing or other support; patients with advanced cancer may be better placed in a hospice. Certainly, the term healthcare service providers includes individuals other than doctors and nurses. It has a broad scope. U.S. federal regulations define a healthcare service provider as a doctor of medicine or osteopathy, podiatrist, dentist, chiropractor, clinical psychologist, optometrist, nurse practitioner, nurse midwife, or clinical social worker who has gained the authority to practice from a state and who performs in the scope of their practice according to state law. The regulations also recognize a Christian Science practitioner and any provider from whom a university or an employee's group health plan will accept medical certification to substantiate a claim for benefits as a healthcare service provider (Legal Information Institute, 2017). Each service provider plays a different role in the healthcare process. IS scholars can investigate information needs for each type of service provider and innovate technology to support these providers' operational work.

5.4.2   Gap 10: Support Rural Hospitals

Rural hospitals face two problems. First, a brain drain of doctors fleeing to cities adversely affects these hospitals because they often lack staff and funds, which further exacerbates the poor healthcare conditions for the disadvantaged populations. Second, these hospitals cannot afford to buy commercial software for hospital management and electronic health recording. The two problems are intertwined. If rural hospitals capitalize on the scale and efficiency of technology, doctors can communicate with mobile technologies, which may ease the understaffing problem. Thus, one solution can solve both problems. One approach involves developing open source software tailored to the needs of small rural hospitals. Another approach involves customizing the existing HIS that large hospitals use for these small rural hospitals.

Regardless of the approach, IS scholars should first investigate the differences in HIS requirements for rural hospitals and for large hospitals in cities. For small rural hospitals, IS scholars can explore how to design a system that connects a community of healthcare providers in isolated rural areas, links multiple small rural hospitals in one (wireless) network, minimizes service quality degradation when network performance is poor, and promotes collaboration despite geographical barriers. Unlike large hospitals in cities that install an advanced HIS, rural hospitals may be willing to use a primitive HIS for the time being. Given rural hospitals' financial constraints, IS scholars may find it challenging to contribute solutions to improve service quality in this setup.

5.4.3 Gap 11: Identify Possible Health Risks

Technology can help practice teams to prepare for possible health risks. They particularly need to undertake such preparation when they work in countries with a high rate of infectious diseases (e.g., HIV/AIDS). In general, practice teams follow the guidelines from the International Center for AIDS Care and Treatment Programs and receive technical assistance. However, the assistance is corrective in nature. With the recent advances related to big data, technologies can identify and assess possible health risks, and then inform practice teams. This approach is preventive in nature. For instance, IS scholars can develop predictive models that mine digital traces, such as disease surveillance, social media, Internet searches in relation to adverse medical events, and mobile phone logs to track patient sentiments and mobility. The big data approach will likely vastly improve the granularity and timeliness of available epidemiological information. This approach augments healthcare hybrid systems rather than supplants traditional surveillance systems and will hopefully provide better prospects for accurate infectious diseases models and forecasts to support practice teams working in rural areas.

5.5 Patients' Physical and Mental Health and Their Lifestyle

5.5.1 Gap 12: Long-term Impact on Patients' Physical Health

Primary HIS focus on improving patients' health outcomes. Prior studies that have examined HIS adoption constitute an important first step to HIS success. After patients and healthcare professionals have adopted a HIS, we should shift our focus to the primary goal: patients' health outcomes. Patients with acute illnesses have a simple health outcome: cured or not cured. In contrast, chronic care focuses on not only curing illness but also enhancing patients' functional status, minimizing their distressing symptoms, prolonging their life through secondary prevention, and enhancing their quality of life.

Future IS research can identify relevant dependent health-related indicators for each chronic illness and examine whether and how HIS can help these patients maintain their health conditions based on the relevant long-term indicators. Without longitudinal data on patients' health, we do not know whether the benefits that HIS have on patients' health last for a short duration, fluctuate, or continue perpetually.

5.5.2 Gap 13: Impact on Patients' Mental Health and Lifestyle

Thus far, HIS research has focused on how technology enables patients to achieve better physical health. However, physical health and mental health are interrelated: physical health problems can lead to increased stress and a high risk of developing mental health problems. Similarly, mental health problems can adversely affect physical health and lead to an increased risk of some physical health problems.

In addition, lifestyle factors (e.g., regular exercise, healthy diet, and no smoking) promote physical and mental health. People with depression and people with schizophrenia are twice and three times as likely to smoke as other people, respectively. Interestingly, better physical and mental health leads to a healthier lifestyle, which forms a feedback loop: physical health, mental health, and lifestyle are all interlinked. How a HIS affects the feedback loop between lifestyle and physical and mental health deserves more attention from IS scholars. Future research can examine the underlying mechanisms for how HIS simultaneously enhance physical and mental health through altering lifestyle. We believe that integrating personalization and gamification into HIS represents a promising direction. In addition, given that people with mental health problems may not realize that they have such problems, IS scholars should adopt a design science approach to enhancing the current text-mining techniques and apply text mining to posts and discussions on social media to uncover the conversation patterns of people with undetected mental health problems. This approach would make practical contributions to preventing depression, anxiety, and suicide.

5.5.3 Gap 14: Technology to Cope with Patients' and Their Families' Depression

Chronic illness causes ongoing stress, and, thus, a patient with such an illness or even the patient's family may have depression and anxiety. To elaborate, these patients confront ongoing health management over many years or even decades. They may face intercurrent acute episodes associated with a chronic condition or other acute illnesses. Chronic illness also leads to family stress. Thus far, the literature has focused merely on the role of HIS in promoting physical health. HIS research should extend the focus from physical health to mental health to help patients and their family members cope with depression and anxiety.

Certainly, researchers need to develop medical technology innovation to prevent acute or recurring pains and ease patients' life, but this goal is medical science in nature and not easy to achieve in the next decade. In the near future, IS scholars can explore solutions to detect, for instance, potential depression and anxiety problems in patients and their families through the websites they browse, their online conversations with healthcare professionals, and their discussions on OHCs and social media. They can apply textual analytics to analyze online textual content to detect whether someone feels miserable and has recurring unpleasant thoughts. In addition, IS scholars can explore how to apply technologies in cognitive behavioral therapy, which technology designers have not yet investigated in detail. For example, researchers could explore whether technology can guide users to control their negative thoughts or motivate them to counteract their behaviors related to poor concentration and thoughts of death. In solving these challenging goals, researchers would save many lives.

6   Conclusion

Governments face increasing pressure to improve the operational efficiency of healthcare organizations while cutting operating costs and ensuring that they maintain adequate healthcare service quality. Technology serves as a key to ease the increasing pressure of healthcare sector demands. In the past decade, IS scholars have allocated substantial effort to research on HIS, which the increasing number of publications in the past decade and well-established research centers worldwide evidences. In this paper, we focus on how HIS can support patients with chronic illness. We describe the basic care model and the chronic care model. Given baby boomers' healthcare service demands, healthcare organizations tend to guide patients to self-manage their healthcare services. Hence, we revised the chronic care model to develop an extended version. We review the literature and analyze and assess the knowledge gaps and research that IS scholars have addressed. Then, we identify important research gaps and suggest future research topics related to chronic care that IS research has not yet addressed. Our results have the potential to stimulate and guide future research on HIS.

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