Healthcare Delivery in the Information Age

Rajeev Bali
Indrit Troshani
Steve Goldberg
Nilmini Wickramasinghe *Editors*

Pervasive Health Knowledge Management

Springer

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Pervasive Health Knowledge Management

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This series is dedicated to Leo Cussen: learned scholar, colleague extraordinare and good friend.

Foreword

The challenges of medical practice have been the same for decades; to provide the best possible medical care and advice to each and every patient. To be well versed in the most up to date evidence based medicine and to be the best doctor one can be.

There has been a change with a steadily increasing pressure for our healthcare system to maintain optimum care. Our population is steadily increasing due to births and immigration without an equal increase in the number of healthcare providers or healthcare funding. People are fortunately living longer and as such there are more patients suffering from a multiple of chronic diseases. To say that the average life expectancy is increasing is a very good thing and something the medical community is proud of. As a result, we are being forced to find new innovative ways to help us be more efficient in caring for our patients so that we can maintain the gold standard of care expected.

Offices like mine are overwhelmed. We cannot always service our patients in a timely fashion. Obtaining appointments with specialists is ridiculously difficult—upsetting for the office and disappointing for the patient.

So, what can we do? Healthcare delivery is becoming less hospital centric with satellite health units reaching out to patients and providing community care. This is expensive. Offices coming together as family health units, where family doctors and specialists are under one roof may improve communication and the processing of patients. Looking to technology, many of us are incorporating electronic medical records' (EMR) as a way to streamline the following of laboratory parameters, booking our patients and facilitating the communication between primary care providers. Our provincial government is developing a Diabetic Registry which will enable the physicians to easily track their diabetic patients with regards to office visits, eye care assessments, and various other parameters that are important to diabetic care. The Ontario Ministry of Health is optimistic that this close tracking of diabetic patients will result in less morbidity and mortality and thus reduced healthcare costs.

There is something missing; an essential piece of the equation for us to be successful in using our new developing technology. In my opinion, patient involvement in self-care is the key to our hope for success. Patients must be active in their own care and must be part of the healthcare team. Our new technology must be used to bring the patient into the loop—so that they can easily communicate and receive

support from their various primary care providers in an efficient, low-cost manner. A lot of excellent care can now be done remotely, especially when dealing with chronic diseases such as diabetes, hypertension, and chronic obstructive lung disease.

Mobile technology, the use of cell phones, may in fact be what we are looking for. It can be used as the key method of transitioning from centralized care to decentralized community care. We would be following chronic diseases in an efficient and inexpensive manner that directly connects the patients with their healthcare providers.

This book edited by Bali, Troshani, Goldberg, and Wickramasinghe serves to highlight not only the benefits of mobile and more especially pervasive technologies to facilitate superior healthcare delivery, but also and more importantly maps out how to proceed in order to move from idea to realization successfully. This book has far-reaching relevance and appeal to practitioners, patients, medical professionals, scholars, and the community at large; i.e., all of us who are impacted by inferior healthcare delivery and wish for things to be better and want to know how a brighter future can be attained.

I hope you enjoy reading this most invaluable work.

October, 2011 Dr. Sheldon Silver

Preface

The healthcare delivery system in the United States is in crisis as noted by several scholars and practitioners. Runaway expenditures and problems with access and affordability of care are plaguing the industry. Several chronic diseases such as diabetes and hypertension consume a disproportionate slice of healthcare services. By some estimates, chronic diseases account for more than 70–75 % of direct healthcare costs. These figures are consistent with global trends which indicate that chronic disease management should be a key consideration for any healthcare system throughout the world.

Diabetes is one of the five major chronic diseases. It afflicts more than 20 million people in the United States and accounts for almost US$ 100 billion in medical costs. The prevalence of diabetes in the United States and worldwide is increasing exponentially. This has led the WHO to now refer to diabetes as the silent epidemic.

It has long been established that technology may play a role in contributing to a more efficient delivery of care that may also assist in controlling costs. Given the exponentially increasing number of incidents predicted for chronic disease in general, and diabetes in particular, coupled with the fact that there exists no cure for patients once they contract a chronic disease, and that if the chronic disease is not well managed then it lead to complex and unpleasant secondary healthcare problems, it would appear prudent indeed to examine the benefits of a pervasive healthcare technology solution to facilitate superior chronic disease management.

Pervasive healthcare is an emerging research discipline focusing on the development and application of pervasive and ubiquitous computing technology for healthcare and wellness. Pervasive healthcare seeks to respond to a variety of pressures on healthcare systems including the increased incidence of lifestyle related and chronic diseases, emerging consumerism in healthcare, need for empowering patients and relatives for self-care and management of their health, and need to provide seamless access for healthcare services independent of time and place.

Pervasive healthcare may be defined from two perspectives. First, it is the development and application of pervasive computing (or ubiquitous computing, ambient intelligence) technologies for healthcare, health, and wellness management. Second, it seeks to make healthcare available to anyone, anytime, and anywhere by removing

locational, time, and other restraints while increasing both the coverage and quality of healthcare.

This book attempts to address the emerging area of pervasive health in a unique fashion. Not only is the field of pervasive health defined but the key management principles, most especially knowledge management, its tools, techniques, and technologies are introduced in order to show how superior pervasive healthcare delivery can be achieved. In addition, this book takes a sociotechnical, patient-centric approach which serves to emphasize the importance of a key triumvirate in healthcare management namely, the focus on people, process and technology. Last but not least, this book discusses in detail a specific example of pervasive health, namely the potential use of a wireless technology solution in the monitoring of diabetic patients. Specifically, it describes the journey from idea to realization and how such a solution contributes to superior chronic disease management.

Given the crisis currently US healthcare system is facing as well as the major dilemmas faced by numerous other healthcare systems throughout the world, the need for a book that proposes to demystify the new frontier of pervasive health and simultaneously offer a solution to facilitate superior chronic disease management could not be greater. We are confident that this book will play a pivotal role in designing and fostering research and understanding of pervasive health, its advancements, and the adoption and diffusion of superior chronic disease management. Moreover, we are confident that scholars, practitioners, those in the community who suffer from chronic disease as well as anyone interested to understand critical issues pertaining to better management of diabetes will find this book invaluable, informative, and enjoyable.

The Editors

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Part I
Why Pervasive Healthcare and KM?

Chapter 1
Introduction

Indrit Troshani and Nilmini Wickramasinghe

Abstract This brief chapter introduces many important concepts and constructs and sets the scene for why a pervasive perspective is a prudent choice for supporting superior healthcare delivery in the current healthcare environment globally.

1.1 Introduction

The need for improvement in the delivery of healthcare is unarguable especially when one looks at the more recent trends of healthcare expenditure for all OECD countries (OECD 2012). In particular, the statistics from the US are most alarming and some scholars and practitioners alike predict that if unchecked US healthcare costs could rise to as much as 20 % of their GNP by 2020 (Porter and Tiesberg 2006).Without a question there is a clear need and urgency for short and long term solutions to this current crisis with regard to delivering cost effective quality healthcare. Naturally, in today's Information Age, such a search has lead to a focus on pervasive information and communication technologies (ICTs). While we clearly believe there is indeed value and merit in applying ICTs to effect superior healthcare delivery, we caution regarding a carte blanche approach and rather advocate a more careful analysis and clear articulation of realizing cost-benefits that are generally promised with ICT implementations. Moreover, we believe that a subset of ICTs, namely, pervasive technologies may indeed hold the key to effecting superior cost effective healthcare delivery.

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1.1.1 Focus of this Section

This section introduces many important concepts and constructs and sets the scene for why a pervasive perspective is a prudent choice for supporting superior healthcare delivery in the current healthcare environment globally. The need for improvement in the delivery of healthcare is unarguable especially when one looks at the more recent trends of healthcare expenditure for all OECD countries (OECD 2012). In particular, the statistics from the US are most alarming and some scholars and practitioners alike predict that if unchecked US healthcare costs could rise to as much as 20 % of their GNP by 2020 (Porter and Tiesberg 2006). Without a question there is a clear need and urgency for short and long term solutions to this current crisis with regard to delivering cost effective quality healthcare. Naturally, in today's Information Age, such a search has lead to a focus on pervasive information and communication technologies (ICTs). While we clearly believe there is indeed value and merit in applying ICTs to effect superior healthcare delivery, we caution regarding a *carte blanche* approach and rather advocate a more careful analysis and clear articulation of realizing cost-benefits that are generally promised with ICT implementations. Moreover, we believe that a subset of ICTs, namely, pervasive technologies may indeed hold the key to effecting superior cost effective healthcare delivery.

1.1.2 The Chapters

The chapters in this section then not only present the case for why pervasive technologies might be appropriate for effecting superior healthcare delivery but also why it is important to also and contemporaneously apply current management principles such as knowledge management to such pervasive technology applications. Specifically, the five chapters that make up this section discuss the following:

Chapter 1 "Pervasive Computing and Healthcare" N. Wickramasinghe. This chapter presents the case that it is only possible to truly leverage the full benefits of pervasive technologies for healthcare delivery, if a network centric perspective is adopted.

Chapter 2 "Implicit and Explicit Knowledge assets in Healthcare" N. Wickramasinghe, introduces the area of knowledge management in the context of healthcare delivery.

Chapter 3 "Regulating Pervasive e-Health Services" I. Troshani and N. Wickramasinghe provides some useful insights relating to implications for regulations and public policy with regard to incorporating pervasive technology solutions into healthcare contexts.

Chapter 4 "e-Health Complexity and Actor-Network Theory" I. Troshani presents an argument why actor-network theory constitutes a suitable methodological approach for improving current understanding of all of the various benefits that pervasive technologies can afford to healthcare delivery given inherent complexity of modern healthcare.

Chapter 5 “e-health Trends” I. Troshani and N. Wickramasinghe, the final chapter in section I provides a discussion of the near future possibilities, and thus, why it behoves healthcare organisations and public policy makers globally to think about incorporating pervasive technology solutions into their healthcare delivery strategies.

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Chapter 2
Pervasive Computing and Healthcare

Nilmini Wickramasinghe

Abstract A confluence of developments has led to the possibility of realizing a vision of pervasive healthcare. These include, but are not limited to, society becoming increasingly mobile, dramatic advances in various areas of technology and computer science, exponentially increasing healthcare costs coupled with workforce issues, the need to provide effective and efficient healthcare, and the change in the makeup of leading diseases most notably the increase in noncommunicable (or chronic) diseases. This is actually a very exciting time in healthcare delivery and one of the major challenges is to prudently adopt and implement appropriate pervasive healthcare solutions. To do this successfully, naturally requires a full appreciation of the key considerations in pervasive computing and healthcare; in particular, an appreciation of network healthcare operations. The objective of this chapter is to provide such a holistic perspective.

Keywords Pervasive computing · Ubiquitous computing · Pervasive healthcare · Network-centric healthcare

2.1 Introduction

The introduction to information communication technologies (ICTs) into healthcare contexts has led to increased access by healthcare providers and patients, more efficient tasks and processes, and a possibility for superior delivery of care (Varshney 2007, 2009; Kern and Jaron 2003; Wells 2003; Lin 1999; von Lubitz et al. 2006). However, contemporaneously we are also seeing an increase in the number of medical errors (US Institute of Medicine Report, o. J) as well as significant cost increases in all OECD countries (Zwicker et al. 2011), which provides significant stress on healthcare systems. In addition, we are also observing a growth in healthcare disparities and the quality of care (Chalassani et al. 2011) Moreover, other important trends include an aging population and a change in the makeup of leading disease and the exponential increase of noncommunicable disease (Wickramasinghe et al. 2011). Simply stated, providing superior healthcare today is indeed challenging.

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A possible solution appears to lie in the use of mobile and wireless technology (Varshney 2007, 2009; Wickramasinghe and Goldberg 2009). In particular, many have suggested that current and emerging wireless technologies (ibid) could improve quality of healthcare delivery both in urban and rural settings as well as decrease medical errors caused by poor or incomplete information. Moreover, in the area of chronic or noncommunicable disease, several scholars believe wireless technologies can provide superior patient self-care (Wickramasinghe et al. 2011; Wickramasinghe and Goldberg 2009). A vision for pervasive healthcare does indeed appear to be a reality and thus what is important is to understand some of the critical considerations that must be addressed in order to realize such a vision. However, it is the contention of this chapter that without consideration of a network-centric perspective, pervasive healthcare solutions will be unable to deliver their full potential benefits.

2.2 Background

Pervasive or ubiquitous computing (the latter term was coined by Mark Weiser in 1988) is fundamentally a postdesktop model of human–computer interaction in which information processing has been thoroughly integrated into everyday objects and activities. In the course of ordinary activities, someone "using" ubiquitous computing engages many computational devices and systems simultaneously, and may not necessarily even be aware that they are doing so. This model is usually considered advancement from the desktop paradigm and is defined as "machines that fit the human environment instead of forcing humans to enter theirs" (http://en.wikipedia.org/wiki/Ubiquitous_computing). Essentially then, ubiquitous is considered to be "... something that is available anywhere, anytime, while pervasive is something that is permeated in the environment" (Varshney 2009, p. 39); however, in the context of a vision for pervasive healthcare the two terms can be considered interchangeable and both are equally necessary to realize a pervasive healthcare vision. Specifically, there exist four major types or categories for pervasive healthcare; namely implantable, wearable, portable, and environmental (Varshney 2007, 2009).

Some of the immediate challenges in such a context include finding Internet use, supporting context awareness, providing energy access, and protecting privacy and trust (Varshney 2007, 2009). However, current successful initiatives include smart homes, mobile and ubiquitous telemedicine to support medical diagnosis, treatment and patient care especially in rural areas, pervasive patient monitoring services ranging from sensors to mobile phones to monitor particular criteria such as blood sugar for diabetes, or if someone has fallen especially in the case of an elderly individual, intelligent emergency monitoring, health aware mobile devices, pervasive life style management, and medical inventory management systems (ibid).

Taken together, on examination of these current pervasive healthcare initiatives, one cannot be criticized for categorizing them as an extension or subset of e-health; namely, as mobile health or m-health. The key is how to translate m-health into

m-healthcare or m-care; i.e., to provide superior care using pervasive technology. To understand this, it is first necessary to understand e-health, its goal and purpose, as well as the doctrine of network-centric healthcare operations.

2.3 e-health

Today, there exist many definitions of e-health but essentially e-health involves the application of ICTs to support and facilitate the range of healthcare functions concerned with the practice and delivery of care (Varshney 2007, 2009; Zwicker et al. 2011). e-health; however, also includes the digitizing of various healthcare processes and tasks including e-billing, e-payment, e-prescription, e-radiology, and e-records (Varshney 2009). Healthcare systems throughout the world are implementing various e-health initiatives in an attempt to gain efficiencies in healthcare delivery and management, improve quality of care, reduce costs and medical errors, and provide more patient-centric healthcare (Zwicker et al. 2011).

Effective conduct of healthcare operations is not only extremely expensive, it is also extremely complex. In fact, most healthcare problems affecting the world have multiple roots involving social, economical, political, and even geographical factors whose combination provides fertile grounds for the spread of illnesses, prevalence of trauma, enhanced mortality, etc. (Akhtar 1991). As a remedy, it has been proposed that, instead of the currently practiced concentration on a specific devastating illness that captures public attention such as HIV/AIDS, a comprehensive "systems approach" offers the best approach to the solution the causative factors of global healthcare problems (Akhtar 1991). Presently, the governments and political bodies of both European Union and of the United States begin to view the "systems approach" as the only viable option (European Institute of Medicine 2003; National Coalition on Healthcare 2004; Kyprianou 2005).

The introduction of ICT into healthcare delivery has changed many aspects of medicine; however, the explosive growth of worldwide healthcare costs indicates that a mere introduction of advanced technology does not solve the problem (von Lubitz and Wickramasinghe 2006b; Onen 2004; Olutimayin 2002; Larson and Society of General Internal medicine (SGIM) Task Force on the Domain of General Internal Medicine 2004). The quest for financial rewards provided by the lucrative healthcare markets of the Western world led to a plethora of dissonant healthcare platforms (e.g., electronic health records) that operate well within circumscribed (regional) networks but fail to provide a unified national or international service (Onen 2004; Olutimayin 2002; Larson and SGIM Task Force on the Domain of General Internal Medicine 2004). In addition, there is a striking lack of standards that would permit seamless interaction or even fusion of nonhealthcare (e.g., economy or local politics) and healthcare knowledge creation and management resources. Thus, despite the massive amount of information that is available to healthcare providers and administrators, despite availability of technologies that, theoretically at least, should act as facilitators and disseminators, the practical side of access to, and the use and administration of

healthcare are characterized by increasing disparity, cost, and burgeoning chaos (Larson and SGIM Task Force on the Domain of General Internal Medicine 2004).

Previous work by von Lubitz and Wickramasinghe (Akhtar 1991; von Lubitz and Wickramasinghe 2006a, c) discusses the general principles and applicability of the military concept of network-centric operations and its adaptation to modern worldwide healthcare activities. Succinctly stated, the doctrine of network-centric healthcare operations is defined as "unhindered networking operations within and among the physical, information, and cognitive domains that govern all activities conducted in healthcare space based on free, multidirectional flow and exchange of information without regard to the involved platforms or platform-systems, and utilizing all available means of ICTs to facilitate such operations" (Akhtar 1991, p. 334). The three domains include the (Akhtar 1991):

1. *Information domain*: Contains all elements, which are required for generation, storage, dissemination/sharing, manipulation of information, and in addition its transformation and dissemination/sharing as knowledge in all its forms.
2. *Physical domain*: Encompasses the structure of the entire environment healthcare operations intended to influence indirectly or directly—political environment, fiscal operations, patient and personnel education, etc.
3. *Cognitive domain*: Relates to all human factors, which affect operations—education, training, experience, motivation, and intuition of individuals involved in the relevant activities.

The proposed network-centric healthcare operations are conducted using a World Healthcare Information Grid (WHIG)—a multidimensional communications network connecting all relevant information acquisition entities (sensors) with information processing, manipulating, and disseminating organizations (nodes). The nodes also serve as knowledge gathering, transforming, generating, and disseminating centers (Fig. 2.1).

At the highest level of complexity, healthcare activities are characterized by multidirectional and unrestricted flow of multispectral data deriving not only from research/clinical/administrative sources but also from fields that may appear to be almost entirely unrelated—economy, politics, social structure, etc. (Akhtar 1991). At the interdisciplinary level, the data exist as highly incompatible entities the access to which is frequently virtually impossible. In network-centric operations, raw data, information, and node-generated knowledge exist in fully compatible formats based on standards that allow automated meshing, manipulation, and reconfiguration. Essentially, network-centric healthcare operations are based on the principles of high-order network computing, with the WHIG serving as a rapid distribution system, and the nodes as the sophisticated processing centers whose task is to act as integrated data-/information-/knowledge-generating sites and DSS/ESS platforms providing high-level, query-sensitive network-wide outputs. The nodes are also capable of extracting and analyzing data and information from healthcare-relevant sensors and electronic data sources (e.g., financial, political, military, geological, law enforcement, infrastructure level, etc.), meshing complex inputs into knowledge blocks relevant to both specific and general healthcare issues. Incorporation of

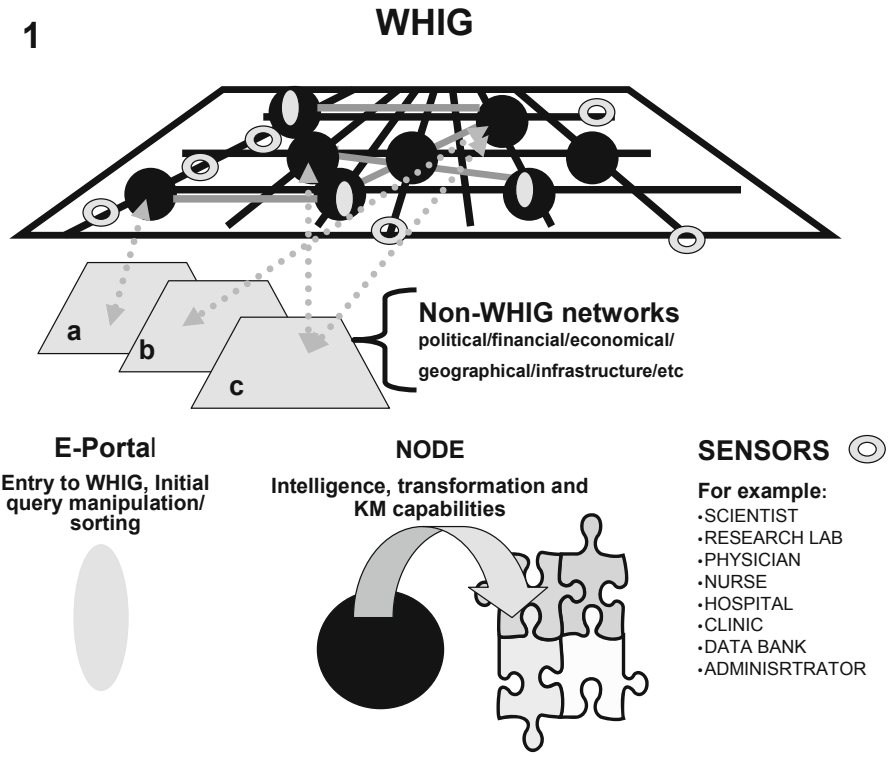

Fig. 2.1 Schematic diagram of a WHIG segment. Sensors feed raw data/information into the network through network-distributed portals. Likewise, data, information, and knowledge queries enter through portals as well. The latter provide entry-level security screening and sorting/routing. Subsequent manipulation, classification, and transformation into information/pertinent knowledge is executed by interconnected nodes. Whenever required, each node can access information/knowledge existing within non-WHIG networks and databases and compare/merge the contents with the contents existing within the WHIG. (Adapted from von Lubitz et al. 2006)

external information in healthcare operations is not only necessary but often critical element that will ultimately determine success of either planned or conducted activities (Olutimayin 2002; Larson and SGIM Task Force on the Domain of General Internal Medicine 2004). The complications resulting either from the failure to include elements external to the essential healthcare activities or consequent to the exclusion caused by either by sheer ignorance or by incompatibility of information/knowledge resource platforms have been amply demonstrated on several occasions (von Lubitz and Wickramasinghe 2006a, c).

The theoretical foundations for the activities characterized by a broad range of multidisciplinary (multispectral) inputs have been synthesized by Boyd as the OODA Loop (Boyd 1987; Akhtar 1991; Larson and SGIM Task Force on the Domain of General Internal Medicine 2004; von Lubitz and Wickramasinghe 2006a) whose practical applications ramify from military activities to global financial/banking