chapter eleven

The business of pervasive healthcare

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11.1 Introduction

The global healthcare industry is facing an unprecedented crisis. With the fast growth of an aging population in the United States and around the world, the demand for affordable but high-quality healthcare is accelerating. According to the U.S. Department of Health and Human Services, by 2050, the retiring baby boomers will require the population of caregivers to more than triple to 6.5 million workers, even though healthcare already accounts for about 15 percent of U.S. gross national product (GNP).[1] This rising demand is placing a tremendous economic burden on governments, private employers, and individual consumers alike. It also becomes a strain on the available capacity of skilled care professionals and nursing homes. Meanwhile, technologies such as personal computers, cell phones, and the Internet continue to transform every aspect of human existence, including healthcare. The advent of miniaturized sensors, wireless networks, and mobile devices is making traditional medical and consumer health devices smarter, cheaper, easier to use, and more ubiquitous. Telehealth and remote monitoring of patients is rapidly becoming an essential part of the new healthcare reality. Together with the increasing adoption of electronic medical records among provider organizations, these technologies hold great potential to transform the healthcare landscape, helping contain cost, improve the quality of care, and enable new classes of services.

The Internet has been a driving force behind the continuing trend of consumer-centric healthcare by opening up the floodgates of consumer health information. About two-thirds of Internet users search for health information.[2] However, an informed consumer is just the beginning. To be effective, health information needs to flow not just from institutions to patients but also from patients to healthcare providers, especially while patients are not in a care facility. In today's healthcare system, whether or not the patient receives the right level of care depends heavily on where the person is. Patients usually get the attention they need as long as they are physically in a hospital, a physician's office, or another professional care facility. As soon as they move out of these facilities, care providers lose touch with these patients, knowing little about what is going on with them and what care they might need. This problem becomes especially evident for people with chronic conditions (e.g., diabetics) and the elderly, who typically live normal lives at their own homes a majority of the time. In this case, the lack of timely information about the patient status and required interventions could lead to costly emergency room visits, hospitalization, and even death.

The recent rise of disease management is a direct response to some of these deficiencies in the current healthcare system by introducing structured, proactive interventions for the targeted population (i.e., chronic, heavy users of healthcare services). Most disease management companies today rely on a "high-touch" approach by having specially trained nurses call individual patients on a periodic basis, providing necessary counseling, coaching, and

education. This approach has led to significant improvements in compliance and reduction in hospitalization.[3] However, its effectiveness is somewhat limited by the lack of real-time visibility to the current status of the patient population.

Until recently, it has been quite costly to support the continuous flow of patient data from patient homes to care providers, largely because doing so requires a dedicated communication and device infrastructure. With the increasing availability of home broadband, wireless networks, and a wide range of consumer health electronics, a de facto end-to-end infrastructure has begun to emerge. This, together with the widespread use of mobile devices, makes it feasible to carry out two-way, continuous interactions between patients and their care providers, regardless of where they are physically located. We use the term "pervasive healthcare" to refer to this new reality. Enabled by a smart environment, pervasive healthcare is always on, always active, and always aware. It encompasses a broad range of telehealth applications including remote patient monitoring, virtual visits, and telemanagement. We believe that the emergence of pervasive healthcare presents both opportunities and challenges for key players in the healthcare ecosystem, including payers, hospitals, clinicians, employers, device manufacturers and, of course, patients.

This chapter explores the potential business implications of pervasive healthcare technologies. First, we provide an overview of the key enabling technologies for pervasive healthcare including consumer health devices, wireless networks, analytic engines, and interaction technologies. Second, we describe the business case: that is, how pervasive computing enables a new type of care model that meets the critical needs of the chronically ill and the rapidly growing elderly population by reducing emergency room visits and shortening hospital stays. Third, we highlight four examples of commercial applications and how they are used to deliver both business values and improved patient outcomes. Finally, we discuss the opportunities pervasive healthcare brings to various stakeholders, including providers, payers, employers, device manufacturers, and patients. We also describe major challenges ahead, including reimbursement and standardization.

11.2 Enabling technologies

Pervasive healthcare is an emerging reality that is made possible by a number of recent technological developments. Figure 11.1 summarizes the four main enabling technologies for pervasive healthcare: health devices, networks, analytics, and interactions.

11.2.1 Health devices

The availability of miniaturized and inexpensive health devices allows the seamless capture of what is currently going on with individual patients and their environments while they are at home and away from a professional

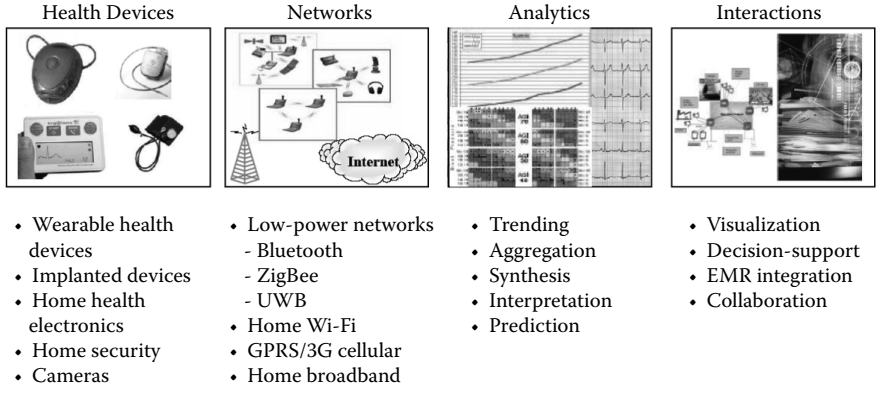

Figure 11.1 Four enabling technologies for pervasive healthcare.

care facility. Examples of the types of information that can be collected include the current location of the patient, activity level, pulse rate, blood pressure level, and sleep and stress patterns. While home health devices like blood pressure cuffs and bathroom scales have been around for years, new computing and communications capabilities not only make these devices smarter but also introduce an entirely new class of devices to the market.

Four areas of device advancement are of particular interest to successful pervasive healthcare. The first area is the increasing digital capacity of health devices. Thanks to Moore's Law (the power of microprocessor technology doubles every eighteen months) and the continuing microelectronics revolution, traditional home health devices have become increasingly digital, equipped with their own microprocessors and capable of actively communicating wired or wirelessly. Some of these devices (e.g., DynaPulse 200M blood pressure cuff) come with software that allows the user to perform sophisticated trend analysis. One can also easily connect these devices to the Internet and securely share the information with doctors and care providers anywhere in the world. For example, A&D Medical manufactures a number of Bluetooth-enabled home devices, including weight scales and blood pressure cuffs, allowing these devices to wirelessly communicate data anywhere in the house and to care providers.

The second area is the miniaturization and consumerization of medical devices. Professional medical services such as ECG and cholesterol testing are moving out of laboratories and into consumer homes. The ecg@Home from HealthFrontier, for example, measures about 4 inches by 3 inches and weighs only 100g. It records and stores electrical heart signals that can be obtained noninvasively by using two built-in electrodes on which the thumbs are placed. With these smaller, more affordable, and easier-to-use devices, consumers can perform the same types of measurements or monitoring that used to be carried out only at clinics or hospitals within the comfort of their own homes.

The third area is the emergence of a new class of health devices that have their roots in the fitness community but have recently begun to appear

in the broader healthcare market. The HealthWear armband from BodyMedia is a good example. Worn on the back of the upper right arm, the armband continuously gathers detailed physiological data like movements, heat flux, skin temperature, and galvanic skin response. Such low-level data provide the basis for inferring important lifestyle patterns, such as energy expenditure, sleep, and exercise, which are useful in a wide range of treatment programs, including weight, sleep, chronic disease, and wellness management. Recognizing this huge growth potential, traditional consumer electronics giants ranging from Samsung to Best Buy have placed a large bet on the consumer health device market by opening new business units and stores dedicated to these products.

Finally, the availability of better and cheaper environmental sensors and cameras has begun to transform homes into intelligent environments where the health status of its residents, not just safety, can be closely monitored. In addition to turnkey solutions from traditional home security service providers, consumers can also purchase such off-the-shelf products as Motorola's HomeSight, which can be seamlessly integrated with a home wireless and broadband infrastructure, allowing family members to view what is going on at their homes through webcams and to receive automatic notifications via email or cell phone in critical situations such as when a smoke detector goes off.

11.2.2 Networks

Closely related to health monitors and electronics are recent developments in wireless networks, including home Wi-Fi, Bluetooth, ZigBee, and Ultra-Wide-Band (UWB). While Internet broadband provides the backbone between the home and remote care providers, the missing link for seamless health monitoring and care delivery lies in the link between different devices around the home, which is aptly called the "last foot" problem. Traditional health devices are stand-alone and do not need to communicate with other devices or applications. However, to enable effective pervasive healthcare, different monitoring devices need to coordinate and transmit data. New devices such as Bodymedia and Fitsense use proprietary, lower-power wireless networks. Early signs indicate that the market at large is beginning to embrace Bluetooth as a de facto standard for in-home health device communication.

11.2.3 Analytics

Once the physiological and behavioral data about an individual's health and their immediate environment are gathered and transmitted to the right place, the next challenge becomes how to make sense of it so that appropriate actions can be taken. For example, with cameras at home, it is possible to monitor the movement and activities of an elderly person in a house. To discern a significant health event (e.g., a fall) requires analytics that interpret

the raw visual input from the cameras and other sensory sources. Ultimately, individualized models are needed for each patient based on the longitudinal data so that predictions can be made about how likely it is that the individual might fall. Thus, preventive measures could be taken before an acute situation develops. Some predictive modeling techniques based on sensory data have already been developed and commercially applied in other industries. Smart Signal, for instance, has successfully used a similarity-based modeling (SBM) application for detecting anomalies and predicting potential failures in complex systems such as aircraft and city bus engines and nuclear power reactors.[4] In doing so, they are able to demonstrate significant savings in maintenance costs while simultaneously reducing downtime for airlines and power companies. As more detailed physiological data about the patient become readily available as a result of the proliferation of health and other sensory devices, a similar analytic approach may be applied to detect anomalies and predict failures in human health, especially for people with chronic conditions. Therefore, these predictive capabilities could help reduce the number of potential emergency room visits and hospitalizations.

11.2.4 Interactions

Healthcare delivery involves a complex web of players, including primary care physicians, specialists, nurses, pharmacists, hospitals, insurers, dieticians, family caregivers, and patients. Each of these players has their unique roles and corresponding informational needs. Even if all the data about a patient are readily available, the hurdle still remains of how to enable the right people to make the best use of the information and insight to make timely and good decisions. The final piece of the technology puzzle for pervasive healthcare is the development of advanced interaction technologies, which include user modeling, visualization, decision support, and collaboration tools. These technologies help people manage their attention and online environments so that they stay focused on what is truly important. They also provide the necessary intelligence that determines the real-time routing of information so that the right people get the right information at the right level of detail.

11.3 The business case

In recent years, tremendous progress has been made on the technology front in terms of improved economics, power, functionality, and usability. Despite that, these technologies are unlikely to gain widespread acceptance by the healthcare industry unless it is shown that they help improve clinical outcomes and provide positive return on investment (ROI). In this section, we focus on the latter. Specifically, we argue that pervasive healthcare offers a promising means for reducing healthcare cost and for addressing the shortage of provider resources. More important, it will be a key enabler for a new model of care that is necessary to address the root cause of the current global

healthcare crisis (i.e., the prevalence of chronic diseases and global aging demographics).

11.3.1 Key business drivers

Perhaps the most important force behind the current and potential widespread use of pervasive healthcare is the need to drive down or at least contain skyrocketing healthcare costs, which affect not just private health insurers but also governments at all levels, employers, and individual consumers. For example, in April 2005 General Motors announced that its earnings for the fiscal year fell far short of expectations, largely due to its increasing healthcare obligations: GM paid in excess of $5 billion in 2005 to insure its workers and retirees. This translates into about $1,500 for every GM car and truck sold.[5] Even as private businesses are willing to take on their fair share of healthcare costs, employees must still shoulder significant increases in both health premiums and out-of-pocket payments in the form of deductibles and co-pays. As shown in Figure 11.2, despite a moderate slowdown in 2004, healthcare premiums in the United States continue to grow at double-digit rates, far exceeding that of overall inflation and workers' compensation.[6]

Early evidence shows that pervasive healthcare can help significantly reduce the cost of care by reducing potential emergency room visits and hospitalizations. An analysis by the New England Healthcare Institute reveals that compared to standard outpatient care, using remote monitoring for heart failure patients reduces rehospitalization rate by 32 percent following a heart failure hospitalization. Based on the average rate of $9,700 for a 5.5-day stay in the hospital for each hospitalization, this amounts to a net savings of $1,861 per patient for the six-month study period.[7] Similar cost savings were also reported by Partners Healthcare and the Veterans Health

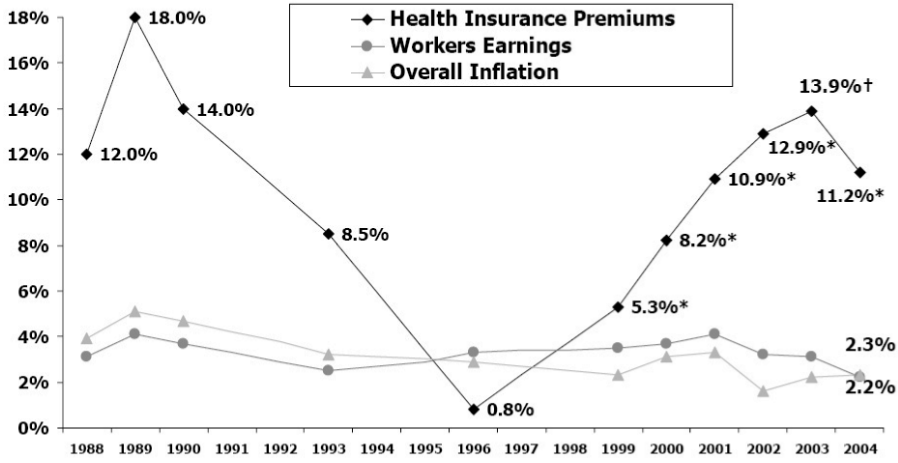

Figure 11.2 Increases in health insurance premiums compared to other indicators.

Administration (VA).[8,9] The VA trial on patients with diabetes, lung disease, and heart failure reported a 35 percent reduction in readmissions and a 60 percent drop in emergency room visits. This translated into a net savings of $23 million across the study population.[10,11]

The second driver for pervasive healthcare is to help improve productivity among provider organizations by addressing increasing shortages of healthcare professionals, ranging from medical technologists to nurses. The worldwide nursing shortage is perhaps most noticeable and critical, because nurses are the primary source of care and support for patients at the most vulnerable points in their lives. Figure 11.3 shows the continuing rise in demand for registered nurses in the United States compared to the dwindling supply. By 2015, demand will exceed supply by 20 percent, quadrupling that of 2000.[12] The problem is especially acute in senior and home care. According to the Center for Medicare and Medicaid Services, 90 percent of long-term care organizations lack sufficient nurse staffing to provide even the most basic care.[13] At these levels, home care agencies are being forced to refuse new admissions due to lack of staffing.

Although most attention about pervasive healthcare currently focuses on cost reduction, pervasive technology can play a vital role in improving caregiver productivity. For example, when a homebound patient can take his or her own vital signs, each visit by a care professional can be shortened by fifteen to twenty minutes by doing the test before the nurse arrives. Additionally, the technology also could eliminate needless weekly visits, with visits prompted only when a monitoring device detects a problem. A recent study by Partners Healthcare shows telemonitored congestive heart failure (CHF) patients required 40 percent fewer nursing visits.[8] In another study, by using its remote cardiac monitoring network, Medtronic reports a 50 percent reduction in the length of follow-up visits.[14] As a result, home care agencies and cardiac clinics are able to handle significantly more patients with the same or even a fewer number of staff.

The third and final driver for pervasive healthcare has to do with the quality of patient care. In its landmark report on issues surrounding the

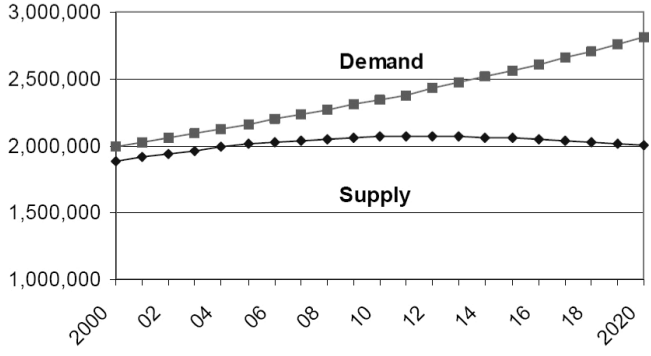

Figure 11.3 Projected RNs supply and demand in the United States, 2000–2010.

quality of care delivery in the United States, the Institute of Medicine (IOM) noted that hospital discharge often signals an abrupt drop in care quality because, when left on their own, patients frequently lack the means, information, discipline, and oversight necessary to care for themselves.[15] One example is patient compliance with prescribed medication plans. A UCLA study of patients immediately after their hospital discharge reveals that 73 percent failed to use at least one medication according to physician instructions and, of all the drugs ordered at discharge, only 32 percent were taken at all.[16] The net result of such noncompliance is poor outcomes in terms of delayed recoveries, complications, and even rehospitalization.

One of the major premises of pervasive healthcare is that it allows patients to continue to receive professional attention and care while they are at home and away from a medical facility. In this continuous care environment, real-time remote monitoring devices can diminish noncompliance behaviors and abnormal physiological developments can be detected promptly. As a result, appropriate intervention action can be taken quickly so that an acute or emergency situation might be averted. This assertion was supported by the results of a six-month, 600-patient study by the VA that showed not just significant cost savings but also a more than 90 percent patient satisfaction rating. Furthermore, patients also reported they were more educated, secure, and better able to manage their own healthcare needs.[11] This increased sense of patients' security was also supported by the result from Medtronic CareLink, which showed that patients and their families enjoyed additional peace of mind knowing they were always remotely connected to the clinic and physicians (see also Section 11.4.1).[14]

Figure 11.4 summarizes the market forces behind the adoption of pervasive healthcare among the various stakeholders. While rising healthcare costs, provider resources shortage, and care quality are the most visible drivers, a closer examination reveals two deeper forces underlying the current crisis: the prevalence of chronic diseases and an aging global population. Because most chronic patients are also elderly, the latter trend will only exasperate the former. In the following two sections, we make a strong case that addressing these two fundamental forces calls for a continuous care model and that pervasive healthcare is an ideal technology enabler for this

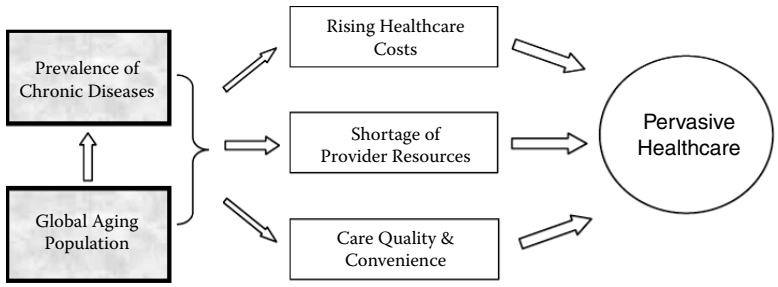

Figure 11.4 Market forces behind the adoption of pervasive healthcare.

new model. The current Medicare chronic care initiatives underway show early signs of movement in this direction, as discussed in more detail in Section 11.3.3.

11.3.2 Calls for a continuous care model

The increase in chronic diseases, including heart disease, diabetes, and asthma, is widely recognized as the number one healthcare challenge. Over 75 percent of U.S. healthcare spending goes to the care of people with chronic conditions. In 2004, nearly half of Americans, or 133 million people, were diagnosed with one or more chronic condition. With the rapidly aging baby-boomer generation and their concomitant health problems, the number of people with chronic conditions is projected to reach 157 million by 2010.[17] Yet the current healthcare system, which is based on an episodic, acute care model, is poorly equipped to meet the needs of this rapidly growing population. Instead, the episodic model is optimized toward "fixing" patients when they have acute problems. This works well for patients who have broken legs or are in need of open heart surgery, but does not work well for patients with Alzheimer's disease or diabetes.

Because chronic illnesses are ongoing conditions that are often not curable, chronically ill patients require daily management and self-care as well as coordinated and timely interventions from healthcare providers. Without appropriate guidance and behaviors such as taking the right medication at the right time, measuring vital signs regularly, and eating properly, a patient's status can deteriorate from manageable symptoms into a more serious condition such as heart failure, asthma attack, or another crisis that requires an emergency room visit or hospitalization. A poorly managed chronic condition can also lead to a number of complications or other illnesses. For example, diabetic patients are at risk of peripheral vascular disease, which can in turn lead to amputation and disability.

Although chronic diseases affect people of all ages, they strike the elderly population particularly hard. For example, congestive heart failure is a leading chronic disease for older adults and accounts for over a quarter of a million deaths each year.[17] The other prevalent aging-related chronic illness is the decline or impairment of cognitive abilities. An estimated 4.5 million Americans suffer from Alzheimer's disease. It is expected that by 2050 this number will rise to between 11.3 and 16 million people.[18] Compared with other chronic diseases, managing these two conditions requires more support and participation from caregivers because patients themselves are often frail and unable to care for themselves.

The prevalence of chronic diseases calls for a continuous care model where patients are empowered to engage in self-care and receive ongoing education and proactive interventions from healthcare providers. The key in this model is having the ability to identify early warning signs of potentially acute problems and to intervene promptly to avert unnecessary complications or trips to emergency rooms. This new model is precisely what

pervasive healthcare attempts to support. With remote monitoring using home and wearable devices and always-on connectivity, real-time alerts and a plethora of other telehealth capabilities become possible. Patients monitored continually by healthcare devices can be automatically provided with reminders about what they need to do. When necessary, care providers on the remote end can also step in to make sure the patient is on the right course or to answer any specific questions. This model provides an effective means to manage patient conditions while they are at home or any other location away from their caregivers. Consequently, it can result in less patient suffering, lower costs, and better use of scarce professional care resources.

The VA is a pioneer in successfully demonstrating the effectiveness and savings in applying pervasive healthcare to chronic disease management. In 2000, the VA funded eight two-year clinical demonstration projects in Florida to test the concept of "aging-in-place" by providing disease management, care coordination, and remote monitoring of veterans in their homes. The published results from these projects showed a 40 percent drop in emergency room visits, a 60 percent decrease in hospitalizations, a 64 percent decline in nursing home admissions, an 88 percent reduction in nursing home bed days of care, and over 90 percent patient satisfaction ratings.[11] Similar positive results were reported from a later expanded program in ten other states and territories.[19] Based on the success of these early pilot programs, in 2003 the VA established the Office of Care Coordination (OCC) to oversee a national rollout of such programs, with the ultimate goal of making the service available to 1.2 million veterans by 2008.

11.3.3 Case study: Chronic care initiatives at Medicare

Medicare is the U.S. federal health insurance program and covers nearly 42 million Americans: 35.4 million seniors and 6.3 million people under the age of sixty-five who have disabilities. The program was first introduced in 1966 as part of amendments to the Social Security Act and has grown steadily over the years. In 2005, Medicare benefits amounted to about $325 billion or 13 percent of the federal budget. This number is expected to grow to $444 billion in 2010.[20] A major reason for this rapid growth in cost is the prevalence of chronic conditions among the Medicare population. Nearly 80 percent of Medicare beneficiaries suffer from at least one of the following chronic conditions: stroke, diabetes, emphysema, heart failure, hypertension, or arthritis. Almost 63 percent have two or more conditions. About 20 percent of beneficiaries have five or more chronic conditions and account for over two-thirds of Medicare spending.[20] This growing burden of chronic diseases constitutes a severe threat to the long-term solvency of the program, prompting Congress to enact the Medicare Modernization Act of 2003 (MMA). In Section 721, the Act specifically calls for voluntary chronic care improvement programs for fee-for-service beneficiaries with one or more chronic conditions.

As part of the MMA implementation, the Centers for Medicare and Medicaid Services established two major chronic improvement initiatives: Medicare Health Support (MHS) and Care Management for High-Cost Beneficiaries (CMHCB). The former is a two-phase program. Phase I, which began in August 2005 and will last for three years, is a piloting phase involving over 180,000 Medicare beneficiaries who suffer from congestive heart failure and complex diabetes. Based on a competitive bidding process, ten healthcare organizations from different geographical areas throughout the United States were selected to operate these pilots. The program is the first-ever nationwide effort to test advanced disease management techniques including the use of remote monitoring and other pervasive healthcare technologies. These techniques are intended to help chronic patients manage their own health, aid in adherence to a physician's treatment plan, offer self-care guidance and support, and enhance communication between patients and care providers. The operators are required to monitor and report on health outcomes including reductions in emergency room visits or hospital readmittance rates, beneficiary satisfaction, and cost savings. Phase II calls for the expansion of these programs or program components to more Medicare beneficiaries. However, this second phase will only move forward if the pilot has successfully achieved its preset goals including the delivery of a 5 percent net savings to the government.

The CMHCB is another three-year demonstration program to help Medicare beneficiaries with high-cost/high-risk chronic conditions to improve their quality of life, prevent complications, and reduce medical expenses. Six organizations were selected to test a direct provider model in coordinating care for such patients by offering them with care support beyond traditional settings. This approach includes the use of home monitoring devices, care coordination, self-care and caregiver support, education and outreach, health reminders, and twenty-four-hour nurse helplines. Among the six pilot organizations is the Advancing Chronic Care through E-Health Networks and Technologies (ACCENT)—a consortium of physician clinics in Oregon and Washington, a home monitoring company, and the American Medical Group Association. The ACCENT-participating medical groups are implementing technology-supported care management that encompasses home-based appliances for electronic health coaching and patient monitoring as well as decision-support tools for providers. In the fall of 2005, the program enrolled about 2,000 Medicare patients with congestive heart failure, chronic obstructive pulmonary disease, and/or diabetes. ACCENT is notable for its first implementation of remote monitoring and coaching across multiple sites and its heavy reliance on pervasive healthcare technologies. The program will document how the physicians' use of these technologies helps high-cost chronic patients to stay healthy, avoid complications, and lower medical costs.

11.4 Examples of commercial applications

In this section, we describe four commercial applications of pervasive healthcare that are already available in the marketplace. While most of them are still at an early stage, these applications offer a glimpse of how established and start-up companies alike are commercializing these technologies and using them to help improve healthcare delivery, namely providing higher quality of patient care at a lower cost.

11.4.1 Remote cardiac monitoring

Heart disease is the number one cause of deaths in the Western world. A quarter of all deaths in the United States—about one thousand deaths a day—are sudden cardiac deaths. Cardiac deaths are often linked to a condition called cardiac arrhythmia or abnormal heart rhythm. As many as 2.2 million Americans are living with one type of arrhythmia called atrial fibrillation. One of the most effective ways to extend and improve the lives of these patients is by surgically implanting small electronic medical devices including pacemakers and implantable cardioverter defibrillators (ICDs). These devices continuously monitor heart rhythms and automatically deliver appropriate electrical therapy if the heart rate becomes irregular. Based on overwhelming clinical evidence about the effectiveness of ICD therapy, the U.S. government has decided to expand ICD coverage significantly to thousands of Medicare beneficiaries who are at an elevated risk for sudden cardiac death.[21]

Once a pacemaker or ICD is implanted, follow-up visits become essential to ensure its proper functioning. Traditionally, these visits must take place in a cardiologist's office every three to six months, depending on the type of device. During these follow-up visits, the nurse or technician noninvasively uses a programmer terminal to gather data from the device. Information about the battery life, lead status, device settings, and other data is evaluated. If necessary, changes in the device settings can also be made during these visits. A physician is called upon when clinical attention is necessary. As the number of patients eligible for ICD therapy has almost doubled in recent years, follow-up visits have increasingly become a bottleneck in patient care.[14]

One of the most significant breakthroughs in arrhythmia management is the emergence of a new generation of pacemakers and ICDs that supports wireless remote monitoring and management. With this capability, physicians are able to evaluate a patient with an implantable cardiac device over the Internet and beyond clinic walls, without requiring the patient to leave home. The patient typically uses a small wireless device at home or on the road to interrogate and collect data about heart and ICD activity. The data are wirelessly transmitted via a standard telephone, cellular, or Internet connection to a remote data center, where the data are then analyzed. Clinicians access patient data by logging onto a secured Web site. Patients and

family members can also view information about devices and conditions on their own secured personalized Web sites.

Remote cardiac monitoring through implanted devices provides clear benefits to device manufacturers, clinicians, and patients. Faced with potential recalls for defective ICDs and pacemakers, the medical device industry has turned to wireless monitoring to keep tabs on their products and minimize potential damages in the case of malfunctioning. For clinicians, the new remote monitoring capability helps improve operational efficiency and enables them to handle a much larger volume of patient flows with the same level of staffing. For example, the average length of time for a follow-up visit for patients using Medtronic CareLink has been reduced by half.[14] Remote cardiac monitoring also leads to better and more efficient patient care. The ready access to patient and device data allows timely problem detection and attention from clinicians. For patients, the most notable improvement is enhanced convenience. Instead of having to schedule and travel to the clinic, over half of the routine follow-ups can be performed in the form of "virtual visits" directly from the comfort of the patient's home. In addition, patients and their families enjoy the peace of mind knowing they are always remotely connected to the clinic and physicians.

The four major implanted cardiac device manufacturers (Biotronik, Guidant, Metronic, and St. Jude Medical) have marketed their own versions of FDA-approved ICDs that support remote monitoring (see Table 11.1). The Biotronik Home Monitoring system received FDA approval in 2001. Aside from being the first system of its kind on the market, two other features set it apart. First, it relies on a Global Standard for Mobile (GSM) cell-phone link to connect the patient to their service center, which means that the patient can be monitored anywhere in the world where GSM coverage is available. Second, the device can be programmed so that when certain important events take place (e.g., the onset of silent arrhythmias), the data are transmitted in real time and the physician can be notified immediately.

Unlike Biotronik Home Monitoring, the St. Jude Medical HouseCall Plus system uses standard telephone lines to transmit ICD data equivalent to a full, in-office device interrogation including electrograms, surface ECGs, delivered therapies, and stored electrograms. It also features live medical professionals to analyze the transmissions immediately and communicate with the patient. Being the latest entrant to the market, the Guidant Latitude Patient Management System features an in-home monitoring unit that can connect to third-party devices via Bluetooth, including weight scales and blood pressure cuffs. In doing so, Guidant opens its patient monitoring platform to accommodate data from sources other than its own devices.

By far, the most widely used remote ICD monitoring is Medtronic CareLink Network, which was originally approved by the FDA in 2002. It is currently available to nearly 530,000 pacemaker and ICD patients and in more than 150 electrophysiology clinics. The system is running in twenty-two VA clinics, and nearly five hundred veterans are being monitored remotely. In total, there are over 37,000 CareLink users in the United

Table 11.1 Remote Cardiac Monitoring from Four Major Medical Devices

Company	Remote Cardiac Monitoring Service	Date of FDA Approval	Number of Users	Special Features
Biotronik	Biotronik Home Monitoring	Oct., 2001	N/A	Real-time data transmission if necessary; GSM cellular network
Guidant	Latitude Patient Management	Sept., 2005	8,000	Home communicator uses Bluetooth and can connect to optional third-party devices such as scale, blood pressure cuff
Medtronic	Medtronic CareLink Network	Jan., 2002	37,000	Reimbursement agreements with major payers across the United States
St. Jude Medical	HouseCall Plus	Nov., 2003	N/A	Live medical professional available to analyze data immediately and communicate with the patient

States.[22] Medtronic attributes its huge success to its ability to work with major health plans and other payer organizations so that clinics and physicians are compensated for providing remote monitoring and "virtual office visits" under either existing or miscellaneous reimbursement codes.

11.4.2 Health Buddy system

Health Hero Network is a leading provider of technology solutions for remote health monitoring and care management. Its Health Buddy system includes monitoring devices, clinical information databases, Internet-enabled decision-support tools, content development tools, and health management programs. The centerpiece of the solution is the Health Buddy appliance, which can transmit patient data to remote healthcare professionals via a telephone line. By using one of the four buttons on the device, the

patient can answer questions about vital signs, symptoms, and behavior. The Buddy Link allows third-party health devices (e.g., glucometers, weight scales, and blood pressure cuffs) to connect to the appliance, enabling the patient to gather and upload vital sign data. At the back end, the iCare Desktop is an Internet-based care management and research tool allowing care professionals to spot trends, assess risk levels, and monitor a large patient population. The Health Hero Network uses these capabilities to deliver daily monitoring and education that promote positive behavioral changes and better compliance from the patient. This is achieved through more than a dozen standard health management programs for common chronic illnesses including diabetes, congestive heart failure, and asthma. Figure 11.5 depicts how these components fit together to form an integrated system.[23]

Since 2001, a number of field pilots have demonstrated that the use of the Health Hero system could lead to cost savings and improvements in patient quality of life and provider satisfaction. The Veterans Integrated Service Network of Florida (VISN 8), for example, used the system in a six-month program involving six hundred patients with chronic conditions including heart disease, lung disease, diabetes, and mental health. The study showed a 74 percent reduction in inpatient, outpatient, and medication costs, which translated to a net savings of $23 million across the study population. Patients also reported they were more educated, more secure, and better able to manage their own healthcare needs.[9] A separate program at the Henry Ford Health System involves over two hundred heart failure patients since 2004. Early results indicate a high patient satisfaction (92 percent), improved compliance (88 percent), and a decrease in ER visits and hospitalization.[24]

The Health Hero system has been used by over 7,000 patients in a number of healthcare organizations, including the VA, Kaiser Permanente, the Henry Ford Health System, and Mercy Health Center in Texas. The VA, by far the largest user, currently uses the system as part of their OCC initiative to improve clinical outcomes and to increase the quality of healthcare for

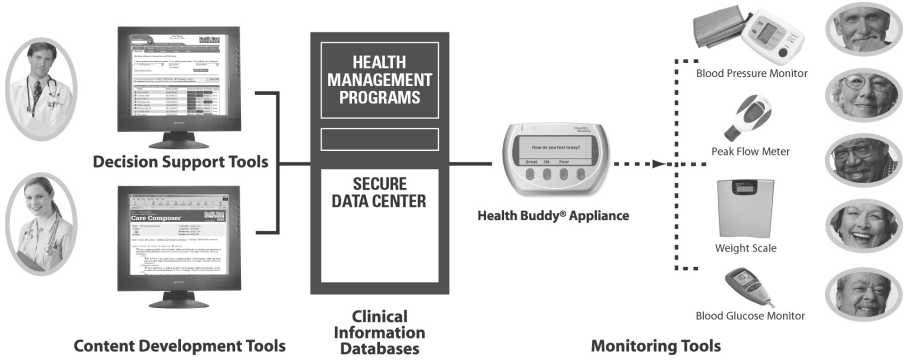

Figure 11.5 Health Buddy system. (With permission from Health Hero Network.)

veterans. More recently, Health Hero Network, together with three Washington State/Oregon-area medical groups, was awarded one of the six demonstration projects by CMS under the Care Management for High-Cost Beneficiaries Demonstration (see Section 11.3.3). Over the course of three years, the program will enroll about 2,000 Medicare patients with severe chronic illnesses including congestive heart failure, chronic obstructive pulmonary disease, and diabetes. Its goal is to employ the Health Buddy system to help improve the quality of life for these patients while significantly reducing costs by preventing hospitalizations.

McKesson—one of the largest healthcare information technology companies—has successfully integrated the Health Buddy system into two of its own solutions: Telehealth Advisor and Horizon Homecare. While Telehealth Advisor provides support for interactive disease management, Horizon Homecare is targeted at the growing number of chronically ill patients who are also in need of home care services. With the new capability, over 17,000 nurses and other clinicians who are currently using Horizon Homecare will have access to an integrated solution, including data from nurse visits and telehealth monitors.

11.4.3 Philips Motiva

Royal Philips is one of the leading providers of innovative telehealth solutions around the world. Through its Medical Systems division, Philips has been offering telemonitoring devices and services that enable disease management companies and other healthcare providers to remotely monitor chronic disease patients at home over a standard telephone line. The latest offering from Philips is called Motiva. Motiva takes remote patient management to a new level by taking advantage of technologies that are available to an increasing number of households, such as broadband connectivity and interactive television. By combining its core competencies in both consumer electronics and medical devices, Philips aims to turn the TV set into a personalized health appliance that connects patients at home with their care providers, providing them a customized healthcare channel or "virtual health coach." By supporting daily personalized interactions and rich multimedia content delivered on demand through a broadband connection to the home television, Motiva enables providers to work with patients with chronic conditions to monitor their conditions, ensure compliance, and drive desired behavioral changes.

At the center of Motiva are a set-top box and a set of wireless health monitoring devices, which are installed in the patient's home at the time of enrollment. Through a secured broadband connection, the patients receive timely reminders and personalized reinforcement messages, educational videos, and feedback on their vital signs, based on a customized care plan defined by their individual care providers. The patients can use the wireless monitoring devices to track their own vital signs including body weight, heart rate, heart rhythm, and blood pressure. Beyond patient compliance,

Motiva's clinical decision-support module helps care providers to better coordinate care delivery and offers more cost-effective patient management.

Motiva is still in a pilot testing and early rollout stage. In June 2005, Philips announced the completion of a four-month pilot study of Motiva in the United States, which involved thirty chronic heart failure patients selected by a New Jersey–based physician group.[25] The key reason for selecting heart failure patients is that most of these patients are over sixty-five, live at home, and want to remain independent for as long as possible. So far, the study is showing overall positive results among both patients and care providers, including:

- Patients show a broad acceptance of using TV to get personalized health information.
- Patients find the TV interface easy to use and find it helps them establish an effective daily routine.
- Patients like getting daily feedback about their vital signs and education videos about how to better manage their diseases.
- Doctors and nurses feel the system helps improve their connection with their patients and makes them more aware of the patients' health status.

To further quantify the clinical and business benefits of Motiva, Philips and Achmea, one of the largest health insurers in the Netherlands, recently started a large-scale clinical evaluation of the system on a randomized population of 630 chronic heart failure patients from eight hospitals in the Rotterdam area of the Netherlands. The twelve-month pilot study will test the usability of the Motiva platform and its impact on hospitalizations, quality of life, mortality, and utilization rates. In May 2006, Philips announced the commercial availability of Motiva in the United States. It expects to roll out the system later in the year in selected European countries.

11.4.4 QuietCare system

Today, over thirty million seniors older than sixty-five years live alone in the United States, and this number is rising daily. According to the Centers for Disease Control and Prevention, one in every three seniors falls in the home every year. The annual medical expense related to falls alone amounts to more than $20 billion in the United States and is projected to climb up to $32 billion by 2010.[24] Furthermore, falls also cause tremendous emotional stress on the elderly and their families as a result of unnecessary hospitalization, premature nursing house placement, and increased dependency. To help ease the financial and emotional burden of elderly care, a new kind of elderly monitoring service is making rapid inroads in the marketplace, and QuietCare is a notable example.

QuietCare is an unobtrusive home health security system first launched in 2002 by Living Independently following more than twelve years of research and development funded partially by the National Institutes of Health and

Aging.[26] At the center of QuietCare are five or six small, wireless activity sensors that are strategically placed in an elderly person's home (i.e., in the kitchen, in the bathroom, near the medication counter, and in the bedroom). Each sensor continuously gathers data about the individual's activities of daily living (ADLs), including waking up, bathroom usage, potential bathroom falls, meal preparation, medication handling, and the room temperature. For example, an alert is generated if a senior fails to visit the medicine cabinet during the day or goes to the bathroom and doesn't come out within an hour. The information is transmitted to a local hub device that periodically relays it to a remote server over the standard telephone line. One unique feature of the system is its ability to learn about each individual's normal ADL patterns over time. Information is analyzed in real time at the data center so that someone at the remote response center can react in a timely fashion to emergencies or emerging problems before they become critical. When certain significant changes or events occur, caregivers can be notified via e-mail, text message, pager, or phone call. Historical information about the user is accessible by authorized personnel via a secured Web site.

Initial results from installations at assisted living facilities have shown that QuietCare is a valuable early detection and warning mechanism. The alerts generated by the system quite accurately reflect what actually takes place in the residents' apartments and can lead to prompt interventions. For example, the alerts because of increased bathroom usage for two residents led to the timely diagnoses and treatment of a urinary tract infection and a bladder problem. Besides helping identify problems before they become emergencies, QuietCare also offers a number of other benefits to care facilities, patients, and patients' families. It enables facilities to utilize resources more optimally by offering 24/7 coverage for certain residents without the cost or intrusion of additional staff. It also provides necessary documentation to detail client needs and staff responses. As a result, the system helps to improve staff accountability and regulatory compliance. Because the system is unobtrusive, it is able to offer enhanced peace of mind to seniors, their family members, and professional caregivers, all without requiring seniors to wear anything or change their normal routines.

QuietCare is one of the first commercially available and affordable systems of its kind. The benefits it has demonstrated in early installations have led ADT—one of the largest home security service providers in North America—to license the technology and market it to U.S. and Canadian consumers as a home health security and medical alert service. ADT's entrance is especially significant because its well-known brand lends instant credibility to this emerging market. Additionally, ADT's extensive experience in customer service, network of contact centers, and very large existing customer base can not only help the initial uptake but also the ultimate scalability of this service to thousands of homes.

ADT offers two levels of monitoring service: QuietCare and QuietCare Plus. Both are designed to help seniors stay independent, avoid medical emergencies, and live in their own home longer, while giving their family

Table 11.2 Cost Comparison between QuietCare and other Modes of Elderly Care[27]

QuietCare	Home Health Aide	Assisted Living Facility	Nursing Home	Hospitalization
$2.99/day	$15/hr 30 hrs/week	$50/day $250/week	$345/day $2,415/week	$1,200/day 8 days/stay $9,600/total stay
$89.95/ month	$2,100/ month	$3,500/ month	$2,524/ month	
$1,079/year	$23,400/year	$42,000/year	$30,288/year	

caregivers peace of mind. At the basic level, ADT monitoring specialists respond to system alerts about a possible bathroom fall, no morning bedroom exit, or unsafe room temperature by both calling the customer's residence and notifying family caregivers via a secured Web page, e-mail, or pager. To provide additional security, seniors and family members can subscribe to QuietCare Plus, which includes Companion Services—ADT's personal emergency response system (PERS). Companion Services include a waterproof button on a personal pendant or wristband and a two-way voice communication system that doubles as a speakerphone with push-button answering. In the case of an emergency, seniors simply push the button. Upon receiving the alarm signal, ADT will send help if needed. In comparison with other means of care, QuietCare offers a cost-effective alternative in helping elderly persons avoid medical emergencies while retaining their independence and dignity, as shown in Table 11.2.

11.5 Opportunities and challenges

Pervasive healthcare applications such as the examples described above offer key stakeholders great opportunities to address their respective priorities. By increasing patient visibility and enabling care providers to take early actions, they provide a lower cost and better quality of care, resulting in a winning proposition for everyone involved in healthcare: patients, clinicians, health plans, employers, government, and family members. Patients will benefit from improved health and quality of life and reduced out-of-pocket costs as a result of less frequent emergency room visits and hospital stays. Better education and support enable the patient to have a significantly increased ability to understand and manage their overall health and well-being. Healthcare providers benefit from improved decision making and enhanced work productivity. Equipped with both a comprehensive patient history and a current picture of a patient's condition, doctors could have more productive and comprehensive office visits with patients. Other potential benefits include more manageable patient loads and better utilization of scarce provider resources, including nurses and hospital beds. Health

plans could reduce insurance premiums and payouts by ensuring that patients are treated proactively. Through unobtrusive monitoring and objective documentation, pervasive healthcare could also help increase compliance and prevent fraudulent claims by providing health insurers with an accurate account of what is actually happening with the patient. Employers win by controlling rising healthcare costs for current and retired employees and their families. Furthermore, better health services ultimately translate into higher worker productivity through lower absenteeism. Governments could ease the burden on taxpayers, who ultimately pay for medical entitlement programs. In 2002, for example, the average per-person healthcare cost in the United States was $5,000, with about 45 percent financed from government funds such as Medicare and Medicaid.[28] Finally, family members can enjoy the healthy company of their loved ones longer and have the peace of mind of knowing that they are receiving any necessary medical attention on a continuous basis.

Pervasive healthcare also provides a tremendous business opportunity for technology companies. The demand for new innovative wearable and home health devices and services will likely continue to grow at a rapid rate. To fully leverage their technology prowess and brand power, well-established firms like Intel, Samsung, Panasonic, and Philips have aggressively expanded into the health device market. Retailers such as Best Buy have opened separate stores to sell such devices. Meanwhile, many start-ups are coming out of the gate to offer a wide range of niche solutions (see Section 11.2.1). Traditional medical device manufacturers, including Medtronic and Guidant, have also added telemetry capabilities to their new generation of devices. As a result, they are able to better differentiate their products as well as create new revenue streams through services (see Section 11.4).

Despite the vast potential of pervasive healthcare, a number of major challenges still lie ahead. Perhaps the foremost barrier is reimbursement. In other words, who will pay for the technology and the services it enables (e.g., remote monitoring and virtual visits)? As long as doctors and hospitals remain unsure about whether they will get paid for these new services, pervasive healthcare is unlikely to be widely adopted. In the current system, the logical answer is funding through health plans and insurers. However, these parties are generally slow in providing coverage for new technologies. Consumers have increasing control over more healthcare dollars through flexible spending and medical saving accounts. However, recent studies show that consumers are reluctant to pay for these services out of their own pockets.[29] In addition to the financing hurdle, this new way of enhancing the interaction between caregiver and patients faces a cultural challenge as well because many doctors and other caregivers have shown resistance to change. This resistance becomes particularly strong when new services require changes in workflow. In addition, some patients, especially those who are elderly and frail, may feel uncomfortable with technology and prefer having doctors and nurses physically present at their bedsides instead of virtually from another location.

Beyond the abovementioned organizational and cultural barriers, there are also a number of technical obstacles including standards, data security, and usability. Due to the large number of parties involved in healthcare delivery, standards are critical to achieving interoperability and seamless services. Currently, there is still a lack of standards in many areas including wireless communications among home and wearable devices, data privacy, and data formats governing information sharing among patients, clinicians, and health plans. As a result, healthcare organizations must choose between incompatible solutions available on the market and must guess which service they feel might eventually win. This uncertainty discourages early adopters and slows down the uptake of these technologies. The other major technical barrier is related to usability, which relates to simpler software user interfaces, form factors, battery lifetime, and so on. Usability is especially important for pervasive healthcare applications because the typical user is an elderly patient with a chronic illness whose goal is to get well, not to learn new technologies.

11.6 Summary and conclusions

This chapter covered business issues surrounding pervasive healthcare. We began by reviewing four key enabling technologies including health monitoring devices and consumer health electronics, wireless networks, analytic engines, and advanced interaction technologies. Next, we presented a detailed business case for pervasive healthcare, discussing how we may apply such technologies to address not just the industry-pressing problems of cost, nursing shortage, and quality but also the root causes of the current healthcare crisis, including the prevalence of chronic conditions and global aging demographics. We then selected four commercial applications to highlight how pervasive healthcare technologies are being used today and what business values and patient outcomes are being delivered. We finished with a discussion of major economic, cultural, and technical challenges that must be overcome for a broader adoption of the technology.

Given the evidence we have provided in this chapter about the value of pervasive healthcare, we believe that this technology will eventually take hold in the marketplace. The continuing commoditization of computing and communications hardware and software and the maturation of sensory devices will make these technologies ever more powerful and affordable. The tremendous economic potential and the resulting improvement in health outcomes are not being overlooked by high-tech companies such as Intel, who are making huge investments and also bringing their aggressive cultures into this market. At the same time, pressured by rising healthcare costs, governments at all levels and private employers as well have finally begun to take actions. The Connecting for Health initiative by the National Health Service (NHS) in the U.K., the chronic care improvement programs at Medicare and the VA, and the telehealth pilot at the Henry Ford Health

System are just a few examples. However, the real catalyst for the broad adoption of pervasive healthcare will be the aging baby boomers. Unlike previous generations, baby boomers are well educated, health-conscious, self-reliant, and truly demanding. They are and will continue to be the key driving force behind consumer-centered healthcare. Because they have been surrounded by computers, the Internet, and cell phones during most of their working years, this generation is also much more technology savvy. Perhaps most important, the baby boomers' control of purse strings is expected to expand significantly as employers and governments continue to shift a larger share of healthcare costs to consumers. This combination of self-determination, technology savviness, aging-related healthcare needs, and spending power among baby boomers will ultimately help make pervasive healthcare a way of life.

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