E-Government/Technology Series

The Role and Use of Wireless Technology in the Management and Monitoring of Chronic Diseases

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IBM Center for
The Business of Government

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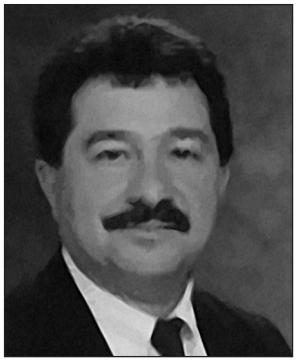
FOREWORD

On behalf of the IBM Center for The Business of Government, we are pleased to present this report, *The Role and Use of Wireless Technology in the Management and Monitoring of Chronic Diseases,* by Professor Elie Geisler and Associate Professor Nilmini Wickramasinghe of the Illinois Institute of Technology.

In the twenty-first century, chronic diseases have replaced infectious diseases as the top cause of death and account for a disproportionate burden on healthcare budgets of governments. This cost will only increase as the population ages.

Carefully monitoring and managing chronic conditions, such as diabetes, is a critical component in reducing emergency care and hospital stays. If care of chronic conditions is well-managed, studies suggest that the risk of complications and death can be reduced by up to 25 percent. Wireless technology, also called "telemedicine," allows diagnosis, treatment, and follow up for at-risk populations such as rural, poor, and elderly patients.



Tom Romeo

This report describes the key barriers to increasing the use of wireless technologies in managing and monitoring chronic diseases. The report describes a range of potential uses of wireless technologies that are now being piloted and that could be expanded to broader populations.

Professors Geisler and Wickramasinghe conclude their report with a series of recommendations to government leaders and public health agencies on expanding the use of telemedicine in ways that will reduce healthcare costs and increase the quality of life for those with chronic diseases.

We hope you find this report is both informative and useful to government leaders now engaged in improving healthcare in America.

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EXECUTIVE SUMMARY

The health care delivery system has many severe challenges. Government agencies and the private sector are alarmed with rising costs, and the decline in quality, access and availability of care, in particular to the underinsured and underserved segments of the population. In the twenty-first century, we are witnessing the increased role of chronic diseases as a global major cause of death and morbidity, replacing communicable diseases, and sapping the resources of an already strained health care delivery system.

The search for short and long term solutions to the crisis in the delivery of care has led to the promise of technology, especially telemedicine and remote care, as a useful alternative to the prevailing models of inpatient care. The utilization of information and communication technologies (ICT) seems particularly suited to provide a cost-effective model of care to the underserved population of patients with chronic diseases.

This report describes the use of ICT, with the focus on the applications of wireless technologies in the remote management of chronic diseases. A review of the literature and the authors' experience are combined in an analysis of the potential of these technologies. Five applications are reviewed. The first is remote home care, including the monitoring of patients' conditions, the use of alert and emergency systems, and remote diagnostics and dispensing of medications. The second is remote intensive care. In cases of rural and underserved populations telemedicine allows for access to critical care. A third application is remote access to clinical specialties, such as teleradiology, telecardiology, telesurgery, and teledermatology. A fourth application is electronic disease registries which allow us to bring underserved patients with chronic diseases into the health care delivery system. Finally, a fifth application is remote care for patients with two or more chronic diseases.

This report contains five recommendations for government leaders and public health agencies:

- The first recommendation calls for supporting the development of telemedicine and wireless technologies. Utilization of these technologies in treating underserved patients with chronic diseases has the potential to improve access to care, quality of care, and to reduce the cost of care—all highly desirable objectives in the reforming of health care delivery.
- The second recommendation is to establish programs to support patients with chronic diseases in the use of these technologies of remote care.
- The third recommendation calls for the development of specific programs with budgetary commitments and workable incentives. The illustrative case study of monitoring diabetes presented in Appendix II shows the intricacies and the difficulties in the application and adoption of telemedicine and wireless technologies by health care delivery organizations. Public agencies should commit workable incentives for health care organizations to more effectively apply these technologies.
- The fourth recommendation calls for the establishment of measures and metrics of success and benefits of these programs and the applications of telemedicine and wireless technologies. As these proposed are pioneered, there ought to be measures of success and benefits which will

allow public and private health organizations to assess their investments in telemedicine and to make the necessary changes for a more effective and successful implementation effort.

- The fifth recommendation calls for collaborative arrangements between stakeholders in the policy making and the delivery of health care services to the underserved patients with chronic diseases. Public agencies, private organizations such as hospitals, professional health organizations and public interest groups must all cooperate in assuring an effective implementation and utilization of telemedicine and wireless technologies for those patients in need.

The need for improvement in the delivery of health care is paramount. As we enter the twenty-first century, we confront the complexity of our health care system and the need to halt the rise in costs and to better the access to care and the quality of care. In a small yet powerful way, telemedicine and wireless technologies may be a critical instrument which can deliver many measurable benefits to segments of patients in dire need of care: the underserved population of patients with chronic diseases. These patients are a major component of the continuing rise in the cost of health care. The benefits we describe in this report will go a long way in contributing to a positive reforming of the health care system.

Introduction

For over two decades, government agencies at all levels have been grappling with the challenges of the healthcare delivery system (Bush, 2004; Geisler and Heller, 1998; Geisler et al., 2003; Institute of Medicine, 2001). Issues of upward-spiraling costs and declines in quality, access, and availability to the citizenry have been constant and perplexing public problems.

The numbers and trends are alarming. Healthcare delivery costs are approaching 16 percent of the gross national product and they are climbing. Over 45 million Americans are uninsured or underinsured. Municipal, county, and state governments are increasingly overburdened by the onerous tasks of providing care for the underserved segments of their population and keeping up with the rising demands of providing affordable and available care to their populations (Centers for Medicare & Medicaid Services, 2007; Rachlis, 2006; Ramani et al., 2008).

In the twenty-first century, chronic diseases have replaced infectious diseases as the top global causes of deaths and morbidity (Centers for Disease Control and Prevention, 2006; Zimmet, 2000; Zuvekas and Cohen, 2007). Noncommunicable diseases—such as cardiovascular disorders and strokes, respiratory illnesses such as asthma, arthritis, and diabetes—now account for more deaths, and for a disproportionate burden on healthcare budgets of governments, than infectious diseases such as tuberculosis, HIV/AIDS, and malaria. This trend is magnified by the demographic realities of this century. The aging of the population and the increased longevity of major segments of the American population are key contributors to the emerging picture of a crisis in the delivery of health services. More patients afflicted by chronic diseases will continue to be a burden on the embattled healthcare delivery system (Windrum, 2008; Wickramasinghe and Geisler, 2008).

In the wake of the search for short- and long-term solutions to the impending crisis in healthcare delivery, the utilization of technologies seems to be a promising and practical alternative. This is particularly viable in the application of information and communication technologies (ICT) to both the clinical and the administrative modes of healthcare delivery (Christensen and Remler, 2007). Known as "e-health," "telemedicine," or "telehealth," this fast-growing aspect of care encompasses the use of telecommunication, wireless, and similar technologies in the management of healthcare—from diagnosis to treatment and follow-up—when providers and patients are located across distances.

This report describes the use of ICT in the care management of chronic diseases. It concentrates on the utilization of wireless technologies as a special case of telemedicine. The application of wireless technology in the management of diabetes is provided as an example of the feasibility and benefits of using this technology.

This report also highlights the need for public health agencies at all levels of government to acquaint themselves with the potential and the promise of wireless technologies in chronic disease care (Institute of Medicine, 1996; Martinez and Gomez, 2008). The report describes the ways in which these applications could contribute to alleviating the burden of delivery of care to the population, particularly to the underserved segments.

Scope of the Problem

Today, public health agencies at all levels of government are faced with the challenge of delivering healthcare services to a population that is becoming older, and increasingly suffering from various chronic illnesses (Thrall, 2005; Wickramasinghe, Geisler et al., 2005). How can this challenge be addressed, and are there feasible solutions that would help providers and payors to serve the public?

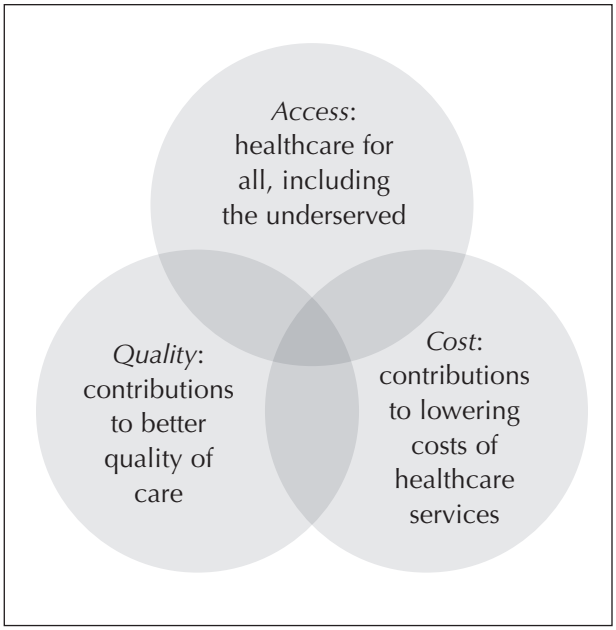
Telemedicine and wireless technologies are partial solutions to this healthcare crisis (Caduano et al., 1995; Tan, 2008). A substantial literature already exists that describes the uses and potential benefits from these technologies for the delivery and outcomes of care in general, and chronic diseases in particular. The next section of this report reviews this literature. The issue is not whether agencies responsible for health care should implement such technologies, but how these agencies should best apply them (Blount et al., 2007; Saxena et al., 2003).

Telemedicine and wireless technologies have been shown to positively contribute to the betterment of healthcare delivery. Figure 1 describes the benefits in terms of improved access, cost, and quality—the three key issues of the crisis in healthcare services.

The use of telemedicine has been extensive in diagnosis and treatment. Wainwright and Wooton (2003) estimate that about 45 percent of telemedicine applications occur in diabetes cases, 15 percent in hypertension cases, 11 percent in cardiac and pulmonary disease cases, and 3 percent in asthma cases. But the utilization of telemedicine in these chronic diseases lags behind its potential and promise. As shown in Figure 1, the application of telemedicine and wireless technologies can produce substantial benefits. The problems of utilization are anchored in concerns and barriers to its implementation (Chan et al., 2002; Kumar and Krupinski, 2008; Norris, 2002; Saxena et al., 2003). The barriers, described in the next section, can be classified into four main clusters: technical, behavioral, managerial, and financial.

Overcoming barriers to the implementation of telemedicine and wireless technologies in chronic diseases is an important part of the problem of using these technologies to improve healthcare delivery.

Figure 1: Contributions of Telemedicine and Wireless Technologies to Healthcare Delivery



This problem is crucial to the policies and strategies of care for public agencies that provide, pay for, and regulate healthcare delivery services. Cost, access, and quality of care are pressing issues that alarmingly tax the resources of these agencies. With chronic diseases increasingly absorbing a growing portion of these resources, it is easy to see that the magnitude of the problem is such that the contributions of telemedicine and wireless technologies would be most welcome (Darkins and Cary, 2000; Lamprinos et al., 2006; Wooton et al., 2006).

Understanding the Application of Telemedicine

Key Issues

For over twenty years, there have been numerous applications of telemedicine in healthcare delivery. In diagnostics and therapeutics, wireless technology has incrementally extended its reach to various medical specialties such as radiology, cardiology, home care, and chronic diseases (Dias-Buxo et al., 2003; Jennett and Watanabe, 2006).

Four key issues emerge in the relevant literature on telemedicine applications. The first is the set of challenges to implementation. This includes the rationales, processes, and methods of implementation of telemedicine and wireless technologies. Researchers have studied ways to better apply these technologies by asking how to match telemedicine technologies to clinical needs and how to overcome the barriers to successful application (Bierman et al., 2002; Kirsch et al., 2007; Moore and Wesson, 2002).

The second key issue is the cost-effectiveness of the application of telemedicine. Researchers explored the economic aspects of telemedicine to determine whether its implementation provides outcomes commensurate with the costs. For example, is the cost of installing telemedicine technologies throughout a hospital and in satellite facilities a viable expenditure? Is the cost of accessing clinical data *anywhere* worth the effort of installing, maintaining, and managing these technologies (Darkins and Cary, 2000)?

The third key issue in the literature is the technology itself. Although wireless and computer technologies have dramatically evolved in the past two decades, there are remaining issues of connectivity, technical sophistication of caregivers, and the integration of these technologies with traditional medical practices (Fraunholz and Unnithan, 2007).

The fourth issue discussed in the literature involves the ethical considerations of remote telemetry (Capuano et al., 1995): the invasive nature of wireless technologies in home care as well as the transmission of clinical personal data over such media as the Internet (Tan, 2008). Ethical and security issues are yet to be fully understood and resolved. Presently, the medical data transmitted over distances is as secure or insecure as the host medium itself. As telemedicine and the use of wireless technologies become routine, concerns about ethics and information security will certainly intensify in the near future (Wickramasinghe and Mills, 2001).

These key issues reflect not only the difficulties in implementing new technologies, but also the unique nature of telemedicine. Health services have traditionally been slower to adopt new technologies than other areas in the economy. Telemedicine and its use of wireless technologies have catapulted healthcare delivery to a level of global outreach unprecedented in traditional medical care. This means a giant leap into reliance on novel methods of communication and state-of-the-art technologies. But the literature also offers solutions and hope that these issues can and will be resolved in time (Christensen and Remler, 2007; Dougherty et al., 1999; Hrejsa et al., 2006).

Barriers to Implementation

The literature identifies four different categories of barriers to the implementation of telemedicine and wireless technologies in healthcare delivery organizations. These barriers are a crucial element in understanding the difficulties involved with the application of government policies that favor and encourage implementation of telemedicine (Bush, 2004; Institute of Medicine, 2001; Parker, 2006).

Reimbursement Issues Impacting Telemedicine

By Aaron T. Steele

Reimbursement has consistently been cited as a significant barrier to the widespread adoption of telemedicine (Dixon et al., 2008; Hersh et al., 2006). Medicare and insurance companies have moved incrementally in changing reimbursement policies for telemedicine and remote monitoring services. Future expansion of electronic health records may provide higher quality data on telemedicine, which will assist in determining future telemedicine reimbursement policy.

A 2006 study for the Agency for Healthcare Research and Quality provided examples of the concerns surrounding telemedicine reimbursement. The study highlighted gaps in high quality evidence on telemedicine use, and concerns that fee-for-service could provide incentives for reimbursable types of care instead of the best quality of care (Hersh et al., 2006). The study noted the need for ongoing research on the efficacy of telemedicine in the health care setting (Hersh et al., 2006).

A 2008 study found that although patients and insurers pay few of the costs, they benefit from quality improvements and cost savings from telemedicine (Litan, 2008). This study recommended a "fee-for-health" approach in which insurance reimbursement policies recognized the value of services that technologies, such as remote monitoring, provide (Litan, 2008).

Federal reimbursement policy changes for telemedicine are proceeding incrementally. The American Telemedicine Association noted the following recent federal telemedicine reimbursement policy changes (ATA, 2009):

- New entities were added as originating sites for payment of telehealth services in H.R. 6331, the Medicare Improvements for Patients and Providers Act of 2008. These entities include hospital-based or critical access hospital-based renal dialysis centers (including satellites), skilled nursing facilities, and community mental health centers.
- U.S. Centers for Medicare & Medicaid Services approved telemedicine reimbursements for skilled nursing facilities.

The potential expansion of electronic health records may offer improved methods to evaluate the efficacy of telemedicine. A key factor will be having standardized, high quality data about telemedicine workload and clinical outcomes across health care settings. This information could then be used to assist policy makers to examine and decide appropriate telemedicine reimbursement policies.

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The first category of barriers is the set of *technical* aspects of telemedicine. Although computer and wireless technologies are now well advanced, there are still challenges in utilization across organizations and professional groups in the healthcare industry. One example is the case of gastroenterology and colonoscopies as means of detecting tumors in the gastrointestinal tract. Innovative technologies such as the "pillcam," or capsule endoscopy, are not yet replacing traditional invasive colonoscopies because they are not yet technologically efficient enough in accuracy and imagery to be implemented on a large scale (Dixon, 2007; Romano, 2006).

Another example of a technical barrier is the computerized or electronic medical record (Gates and Urquat, 2007). This area of healthcare technology has received much attention in the past two decades, including the attention of the federal gov-

ernment (Bush, 2004). Factors that have impeded the large-scale implementation of these technologies include issues of data security, ethical considerations, and ownership of the data warehouses (Ford et al., 2006). From the technological perspective, the puny rate of implementation is largely due to issues of connectivity and coordination with other processes, activities, and institutional correlations of clinical care and health administration.

The second category of barriers is the set of *behavioral* factors that tend to impede the successful implementation of telemedicine and wireless technologies (Deutscher et al., 2008). Clinicians tend to show aversion to changes in their mode of practice. Technical changes in particular are not readily accepted unless they can clearly demonstrate improved performance. When images are not as precise in the electronic mode, the technology may not be well received.

Threats and challenges to the traditional practice of medicine may also result in resistance to the implementation of telemedicine. In addition, different state laws and regulations may impede the practice of medicine across state lines and geographical distances. Although many of these issues have already been resolved, clinicians may still be hesitant regarding the applications of telemedicine (Darkins and Cary, 2000).

Economic and *financial* factors compose the third category of barriers. The cost of implementing telemedicine includes the equipment, software, and training of caregivers. Healthcare providers carefully assess the cost effectiveness of these technologies, but there are still difficulties in precise evaluations of outcomes and benefits from telemedicine (Krizner, 2008; Povich, 2008).

Finally, the fourth category of barriers is the set of *managerial* and *organizational* factors. These include the lack of support, or only lukewarm support, from senior management to the implementation of telemedicine. Partly because of their inability to clearly assess benefits and partly due to the lack of resources for investments in new technologies, senior managers in healthcare delivery organizations tend to delay or withhold support for the implementation of telemedicine (Paavola et al., 2006).

Critical Success Factors

Government health policy makers need to realistically assess the barriers to implementation for programs they support. Technical change in general, and telemedicine in particular, are attractive solutions to the growing healthcare crisis. But successful implementations of such initiatives often fail because policy makers do not recognize, or fail to consider, the powerful influence of barriers to implementation.

An important tool in the effort to evaluate the potential application of telemedicine is for government leaders to have a coherent list of the Critical Success Factors (CSFs) of telemedicine.

How do we *know* that telemedicine has been successful? Success factors are grouped into three categories.

The first is the accomplishment of goals. Has the implementation of telemedicine accomplished the goals set for this mode of care services? (Nesbitt et al., 2006) The goals are the same as those used in traditional care: clinical improvement of patients, fewer medical errors, improved quality of care, improved communication among caregivers, and improved access to and availability of care (Krizner, 2008).

The second category of critical success factors is the set of measurable benefits. Has telemedicine produced outcomes that are cost effective? In other words, was this investment worth it? Has the institution achieved the intended goals at a cost that made it all worthwhile?

The third category of critical success factors is the perceptions of stakeholders. Are the stakeholders (regulators, payors, patients, community groups) satisfied with the applications of telemedicine? Do they perceive this technology to have contributed to their desires and interests?

The Role of Government

As a major payor of healthcare delivery costs and the pay regulator of the sector, the government is deeply involved with the practice, funding, and changes in the sector. The support and actual involvement of government agencies make all the

difference in the level of implementation of telemedicine and wireless technologies.

The case of Finland is an excellent example. Finland, a Nordic country in northern Europe, has a vast geography and long winters. But Finland has only about 5 million inhabitants—a density of only 40 people per square mile. Due to the dispersion of its population, the Finnish government has undertaken a major project to implement telemedicine throughout the country. The objective was the provision of healthcare across geographical distances to as many Finnish citizens as possible, regardless of their location (Paavola et al., 2006; Weinstein et al., 2007). This was a concerted government effort involving hospital districts, industry, research institutes, universities, civic organizations, and a host of government agencies. Finland is currently recognized as the leader in applications of telehealth, wireless technology, and telemedicine in the European Union (Paavola et al., 2006).

The widespread implementation of telemedicine in Finland has produced measurable results. Nationwide, health services are now provided to over 1 million people who formerly had limited access to care (Paavola et al., 2006). Wireless technologies and government involvement are crucial to this project's success.

Regardless of the mode of funding health services, the role of government in actively supporting telemedicine is essential to its success. In the American model, the federal and state governments fund about half the national health care cost. In Finland, healthcare is fully supported by public funds. The role of the American government is therefore a function of a policy which focuses on improved health services delivery to as many people as possible in rural areas, urban underserved populations, and those with limited access to care (National Foundation for Infectious Diseases, 2002; Suwattee et al., 2003).

In the United States, there have been several initiatives by government organizations in the application of home care and telemedicine. For example, the Department of Veterans Affairs (VA) has a major telehealth program. In 2008, some 34,000 patients used telemedicine technologies, saving thousands of office visits (Joch, 2008). The VA also implemented telemedicine programs in rural areas (Cross, 2007). These initiatives have produced measurable savings (Hayes, 2008). In addition, the Military Health System (MHS) has created the Telemedicine Advanced Technology Research Center (TATRC), conducting collaborative studies of telemedicine with industry and academic institutions (MHS, 2008).

Understanding Telemedicine—Key Lessons

- Chronic diseases consume three-quarters of over $2 trillion of our nation's healthcare expenditures. Worldwide, over half the health-related deaths are from chronic diseases.
- The uninsured and underinsured are especially at risk from chronic diseases and the lack of adequate care of these diseases.
- Telemedicine and wireless technology are on a rapid growth trend—solving problems in the monitoring and management of home care, particularly in the case of chronic diseases and uninsured and underserved patients.
- Hospitals are receptive to promising technological solutions to the management of chronic diseases. Implementation of these technologies, such as wireless and telemedicine, require demonstrative benefits.
- Small and incremental solutions of wireless technologies can produce significant benefits in managing chronic diseases and home care for underserved patients.

The role of government in the implementation of these technologies seems to be threefold. Government agencies at the federal and state levels act as pioneers and initiators of programs to try innovative healthcare delivery technologies. Government organizations also act as enablers for the healthcare industry through cooperative endeavors and the funding of new applications. Third, government agencies act as regulators by providing oversight and guidance where new technologies are applied in areas with ethical and other public concerns.

Examples of the complex role of government in telemedicine include several demonstration programs spearheaded by the Department of Health and Human Services (HHS). Some are in the form of focused grants for licensure portability, congressionally mandated telehealth programs, telehealth

Home Telehealth at the Department of Veterans Affairs

By Mark A. Abramson

Since 2003, the Veterans Health Administration (VHA) in the Department of Veterans Affairs has been operating a national home telehealth program called Care Coordination/Home Telehealth (CCHT). The purpose of the program is "to coordinate the care of veteran patients with chronic conditions and avoid their unnecessary admission to long-term institutional care" (Darkins, Ryan, Kobb, Foster, Edmonson, Wakefield, and Lancaster, 2008).

The program is now serving over 31,000 veterans, with anticipated growth to 50,000 veterans by 2011. CCHT provides routine noninstitutional care and chronic care to veterans with conditions such as diabetes, congestive heart failure, hypertension, and pulmonary disease. After enrolling in the CCHT program, each veteran is assigned a care coordinator. The care coordinator selects the appropriate home telehealth technology, provides training to the patient and caregiver, reviews telemonitoring data, and provides active care or case management as needed. Telehealth technologies include videophones, messaging devices, biometric devices, digital cameras, and telemonitoring devices. Messaging, monitoring, video and digital imaging functions are increasingly coexisting on the same device. Promoting patient self-management is one of the major goals of the program.

The CCHT program has been a clear success and can serve as a model for the nation's health care system. It has proven that home telehealth can be provided to patients with chronic diseases on a far larger scale than any such initiative to date. Positive outcomes from the program include:

- Patient satisfaction surveys found a mean 86 percent satisfaction score
- Participants had a 19.74 percent reduction in hospital admissions
- Participants had a 25.31 percent reduction in bed days of care
- The cost of CCHT is $1,600 per patient per annum, which compares to the direct cost of VHA's home based primary care services of $13,121 per annum

The positive outcomes replicated VHA's experience with a pilot program conducted between 2000 and 2003 on which CCHT is based. Another cost-avoidance benefit found in both the CCHT experience and other pilots is the reduction in staff travel to visit patients in their home. Such telehealth initiatives hold the promise for both improving the health of patients and reducing the national cost of healthcare.

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resource centers, and telehealth network programs (HHS, 2008).

Another organization active in telemedicine is the Joint Working Group on Telehealth (JWGT). This interagency organization coordinates funding by its members to prevent overlap, share information, and develop actions to reduce barriers and promote the use of telemedicine technologies. Among the members of the group are the Departments of Agriculture, Commerce, Defense, Education, Health and Human Services, Justice, State, Veterans Affairs, the Federal Communications Commission, the National Aeronautics and Space Administration, and the Appalachian Regional Commission.

Summary: Why This Is Important and What Should Be Done About It

The literature has produced ample evidence that chronic disease care is rapidly expanding in cost and criticality to the healthcare delivery system in America. There is also evidence that telemedicine and wireless technologies have the potential to improve clinical care and contribute to reducing the cost of healthcare delivery.

Chronic diseases such as cardio-pulmonary ailments, arthritis, and diabetes consume a disproportionate share of healthcare expenses, with estimates of over 60 percent of total costs of delivery. Moreover, the

total cost to *society* in lost economic earnings and the burden inflicted by patients upon their families and social agencies that support them is even higher.

The total burden of chronic diseases is in the hundreds of billions of dollars. (Diabetes alone is estimated to have an annual cost to society of over $150 billion.) This is clearly a very crucial problem for our government leaders in both the healthcare arena and the overall arena of establishing and executing social and economic policies (Christensen and Remler, 2007). It is therefore abundantly clear that any contributions of information and telecommunication technologies to improving this problem and to reducing the social burden would be highly welcomed and embraced by policy makers and government leaders.

The literature also offers lessons on the progress of telemedicine and the use of wireless technology in healthcare delivery. In the past several decades there has been tremendous progress in the implementation and utilization of information and communication technologies in clinical care (Doarn, 2008). The barriers and challenges to telemedicine are increasingly being overcome, in many instances with the active participation of government health agencies (Lavine, 2008).

Presently, it is also widely accepted that chronic diseases are a major menace to the country's health and to its economic welfare. These diseases are also a major burden on the uninsured and underserved populations. One lesson from the literature is the ability to learn from the examples of other countries, such as Finland, and their success in implementing telemedicine and wireless technologies for healthcare delivery in general and for chronic diseases in particular (Palmas et al., 2006; Smith and Maynard, 2004).

The critical state of affairs in how chronic diseases influence our welfare and the fact that telemedicine may offer a plausible solution are the foundation for what should be aggressive government action. The private healthcare sector has been actively implementing such technology solutions but much more needs to be done. As the main player in the national healthcare scene, the government—at all levels—must be the driving force in forging ahead with an accelerated rate of adoption of telemedicine, particularly targeted to the rural and underserved segments of the population (Groves et al., 2008; Hanratty et al., 2008).

Applications of Telemedicine and Wireless Technology to Underserved And Disadvantaged Populations

Scope of the Problem

Today there is a vast segment of the population which is uninsured or underinsured. Their number is estimated at 45 million people (Wickramasinghe and Geisler, 2008). This means that almost 15 percent of the population is underserved by the national healthcare delivery system. Underservice is generally measured by restricted access to care, lack of adequate clinical follow-up, availability, and affordability of many specialized health services (Lorence and Park, 2008).

Contrary to the conventional wisdom that many uninsured and underinsured are young and healthy adults who prefer to forego health insurance, Wilper et al. (2008) have concluded that this population includes people of all ages and health conditions. A survey of over twelve thousand patients, ages 18 to 64 years, revealed a disturbing picture (Wilper et al., 2008). They estimated that over 11 million uninsured Americans suffer from chronic diseases. Hence, chronically ill patients who are underinsured or uninsured are more likely to be underserved by medical care and more likely to suffer disability and untimely death from these chronic diseases.

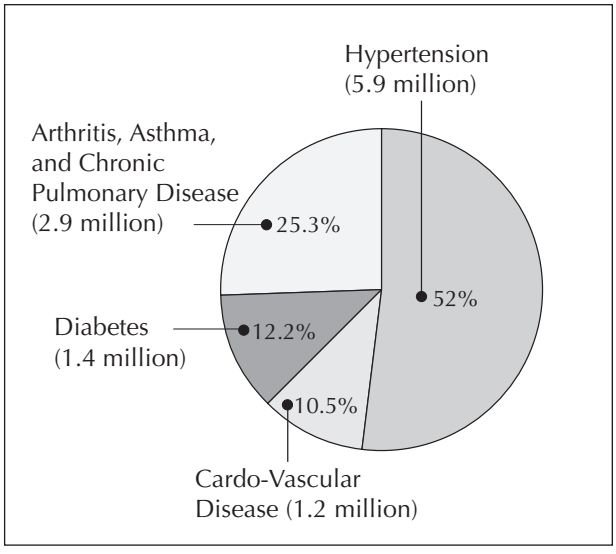
There is undoubtedly a serious crisis in the confluence of the underserved population and those in it who suffer from chronic diseases and who lack adequate care that is available to the uninsured. This crisis comprises the 11 million Americans who are not adequately integrated into the national healthcare delivery network. These patients flood the emergency rooms of urban and rural hospitals. With lack of adequate care, they are also a burden on the economy: their disabilities and morbidity are challenging the nation's workforce and its social services (Panse et al., 2007).

Telemedicine and Wireless Technology as Potential Solutions

We focus on the applications of telemedicine and wireless technology in the underserved population with chronic diseases because of two reasons. First, it is a national crisis. Second, public funds are used to pay the lion's share of the cost of this segment. Hence, this is a crisis of paramount importance and urgency to government health leaders and policymakers (Christensen and Remler, 2007).

The application of telemedicine in this segment of the population is related to the nature of chronic diseases that afflict these patients. Figure 2 shows the distribution of chronic diseases among the estimated 11.5 million underserved patients.

Figure 2: Distribution of Chronic Diseases Among Underserved Patients (Underinsured and Uninsured) in the United States in 2004



Source: *Wilper et al., 2008*

A compounding factor in the intensification of this crisis is the mix of demographic trends and worsening economic conditions. As the American population ages with the baby boomers entering into their sixties, the incidence of chronic diseases will naturally grow. Economic constraints are likely also to push higher the number of underinsured and uninsured patients with chronic diseases. Wilper et al. (2008) estimated that the number of uninsured with chronic diseases would be about 11 million in 2008 (an increase of almost 40 percent in the four year period 2004-2008). If this trend continues and if no action is taken today, the nation will probably face a crisis of 28 million uninsured and underserved patients with chronic diseases by the year 2020. The public onus to care for this segment of the population would be well beyond the coping abilities of government agencies.

So what can telemedicine and wireless technology do to alleviate this crisis? We have shown in Figure 1 that such technologies contribute to better *access*, *cost* reductions and savings, and to improved *quality* of care. In the specific case of patients who are underserved or in rural locations and who are also afflicted with chronic diseases, these technologies can help in five key modalities, discussed below.

Applications of Telemedicine and Wireless Technology in Underserved or Rural Populations with Chronic Diseases

- **Remote Home Care**
  Includes monitoring patients' conditions, alert, and emergency systems, and remote dispensing of medications.
- **Remote Intensive Care**
  Increased reach of critical care clinicians, since many underserved use the emergency departments as primary care outlets.
- **Remote Access To Clinical Specialties**
  Improved access to teleradiology, telecardiology, telesurgery, telepathology, teleophthalmology, teledermatology, etc.
- **Electronic Disease Registries**
  Many patients who are underserved exist under the radar of public health, and their chronic conditions are unknown. Electronic and wireless technology can assist in setting up registries.
- **Remote Care for Debilitating Conditions of Patients with Two or More Chronic Diseases**
  Remote care for patients with, for example, diabetes and cardiovascular disease.

Remote Home Care

Applying telemedicine and wireless technology for remote home care is a promising endeavor. Public health leaders should encourage and support initiatives that foster remote homecare. This mode of care delivery has been shown to be much less expensive than hospitalization. In addition, for the uninsured and underserved who use the emergency departments of hospitals as their primary care outlet, remote home care may be the "best prescribed mode" for delivery of care in a highly cost-effective way (Groves et al., 2008; Palmas et al., 2006).

Remote home care is manifested in two modes of delivery of care. The first is by remotely and wirelessly monitoring the vital signs and other clinical indicators in patients with chronic diseases (Santamore et al., 2008). The second mode is remote clinical treatment, including administration of medications and making decisions as to the disposition of patients, whether remaining in their home or transported to a medical facility. Patients receive routine monitoring of their condition and thus are less prone to be rushed to the emergency room (Biermann, 2002). By being under constant observation, patients remain in the comfort of their home, yet are clinically monitored for changes in their chronic conditions (Montori, 2004).

In the case of rural populations, home care allows patients with chronic diseases the same advantages that urban patients enjoy at a very affordable cost to the payors—including the government programs of Medicare and Medicaid. Telemedicine and wireless technology make geographic distances disappear: rural patients can now be constantly monitored by clinicians across states and even continents (Arora et al., 2007; Balin and Singh, 2007).

Remote home care can also reduce the cost of treating chronic diseases by at least 50 percent, in addition to providing documented improvements in the quality of care and increased access to care (Nesbitt

et al., 2006). Remote monitoring allows caregivers to "triage" chronic patients before dispatching them to the emergency room. Monitoring also consists of the remote dispensing of medications through reminders by phone or other electronic means, even by assuring through direct viewing observation that the patient ingested the prescribed medication (Montori et al., 2005).

The remote monitoring of cardiac and diabetes patients is a good example of remote home care. In the case of diabetes, vital signs and levels of blood glucose are measured periodically in the home. The results are wirelessly transferred to a database in a hospital a few city blocks away or even across the country. Caretakers monitor these readings in real time and decide the necessary course of action.

In Appendix II we describe a case in a large hospital in Chicago where a system is being installed for the remote management and monitoring of patients with diabetes. The system utilizes cellular telephones. Patients are able to send readings of their blood glucose to a hospital unit and the medical staff can react—in real time—and decide on a course of action for the patient.

Remote Intensive Care

Emergency rooms of hospitals are the main venue for primary healthcare services for the poor, urban, underserved, and uninsured patients with chronic diseases. Remote intensive care, including telesurgery (remote surgery), is a well suited mode of care delivery for this very costly and inefficient form of health services (Groves et al., 2008). Such a remote intensive care unit (ICU) allows a clinical center, located near or very far from the patient, to monitor multiple patients and to conduct remote surgery. The use of robotics in surgery is an illustration of remote intensive care. Expert surgeons direct operations from distances, even from around the globe. They can remotely manipulate robots and wirelessly assist local surgeons with surgical procedures.

For public health leaders this mode of healthcare delivery is a desirable use of technology. It expands services to the uninsured and to rural populations at very reasonable costs. It also allows for access to quality care to those segments of the population until now devoid of such care.

Remote Access to Clinical Specialists

The literature contains ample descriptions of how telemedicine fosters the remote access to various clinical specialties: teleradiology, telecardiology, telepathology, teleophthalmology, and even telepsychiatry. In the current framework of our healthcare system, many such specialists tend to be concentrated in large urban areas. There are shortages of specialists in rural areas and in less affluent urban localities. Remote access to these specialists by means of wireless technology in effect helps to close the gap between urban and rural, and between rich and poor urban areas.

For public health leaders this represents a very desirable instrument of social policy, whereby a "specialties divide" is somewhat bridged and the underserved populations are now able to access such elusive specialties. Arora et al. (2007) have described such a project for remote care of patients with chronic hepatitis C in New Mexico. Access, quality of care, and continuity of care by highly desirable specialists can now be a reality for uninsured and underserved populations. From a public health perspective, the results are far-reaching, in that improved care of these patients with chronic diseases provides a boost to the economy, an important social good, and in the longer term a substantial decrease in the cost of national healthcare services.

Electronic Disease Registries

Information about diseases and patients is an essential ingredient for effective health policy. Health leaders in all levels of government must rely on comprehensive, accurate, and current information about patients, and what diseases they suffer from, so that adequate decisions can be made and scarce resources can be efficiently allocated.

The problem of obtaining good information is compounded when the patients of chronic diseases are the uninsured and the underinsured. Many of these patients exist "under the radar" of public health agencies and their chronic conditions are therefore unknown. Since they are largely uninsured, they also exist outside the information networks of the private insurers. Thus, public health leaders are obliged to make critical decisions on the allocation of public resources based on estimates rather than accurate information.

With the emergence of electronic medical records, a new chapter may be written in the collection of information from the uninsured and underinsured populations of patients. There are several developments that can bring the uninsured into the electronic age. The first development is the role that electronic medical records play in the continuity of care. As patients, including the uninsured, move through the healthcare delivery system, their records can be transferred and shared electronically—as a condition for treatment in, for example, charity clinics and hospitals.

While maintaining all HIPAA (Health Insurance Portability and Accountability Act of 1996) safeguards, the patients' information and the continuing care of their conditions can be accumulated and shared with public health agencies without infringing on patients' privacy needs.

The second development is the role of wireless technology in applications of electronic medical records, in general, and for the uninsured especially, has recently emerged as an important instrument for the registry of the uninsured (Waegemann, 2008). The ubiquitous use of cellular phones is increasingly becoming a preferred means of communication between patients and their providers. At the point of care and throughout the disease management process, the patient identifiers (such as age, gender, and insurance status) and clinical data can be electronically stored and shared without compromising the patient's privacy or the sharing of such information with other, non-health-related government agencies.

The third development—as we illustrate in the case of wireless use in diabetes in Appendix II—is the cellular phone in use by patients becomes, in itself, a data resource. This phone also serves as a vital instrument in medical emergencies. Upon contacting the medical responders, the cell phone can transmit the necessary data on the patient and her/his medical history. We reiterate that such a use by underinsured patients will be possible when they are convinced that their security and privacy are protected and the data thus obtained will be used for medical purposes of tracking chronic diseases, *not individual patients*. We should also emphasize that the field of electronic medical records is still in its infancy. Paper records are still very much in use, particularly by small medical practices. As electronic medical records become more ubiquitous and evolve into a widely shared network of clinical and administrative data, the incorporation of wireless technology will be much more effective and acceptable by all parties.

Public health leaders should therefore view these developments as a positive trend in ensuring a more accurate and useful network of health information. This network, particularly in the case of underinsured and uninsured patients with chronic diseases, will help these leaders to make much better decisions on such a critical problem. The savings in lives and morbidity of these "forgotten" patients would perhaps be in the thousands per year. Similarly, the savings in health costs to the government should be in the many millions of dollars each year.

Remote Care for Debilitating Conditions of Patients with Two or More Chronic Diseases

A subset of the uninsured and underinsured population of patients with chronic diseases includes the more serious and debilitating cases who simultaneously suffer from two or more chronic illnesses, such as diabetes and cardiovascular conditions. For government health leaders this subset is of special interest. Patients with multiple debilitating chronic diseases need more care than other segments with a single chronic condition. Hence, they are much more onerous on the public health system and on the economy in general because of the more frequent recurrences of their conditions.

Remote care and the use of wireless technology seem viable options for reducing the costs associated with such patients and for providing them with a more affordable and more available modicum of care. By getting timely help to these patients with an acceptable level of quality of care, there is a good possibility that many lives can be saved and the burden of these patients on the public funding of health care can be reduced.

Public health leaders need to consider this sub-segment of underserved patients with multiple chronic diseases as a "poster child" for the application of remote care and wireless technology. Using these advances in technology would produce rapid and substantial results by improving the care for these patients and by reducing their burden on the public. Therefore, these patients can be an excellent illustration of the success of adequately channeled remote care and wireless technology (Panse et al., 2007).

From Teleconsultation to Telesurgery

Applications of telemedicine, home care, and wireless technology vary by the level of sophistication and the interface with patients. Initial uses of such technologies involve teleconsultation, whereby patients are able to interact with providers across distances. Since the invention of the telephone, such interaction has been feasible with people relating symptoms via the telephone to their provider, describing conditions and vital signs of themselves or their family and friends.

The difference between simply using a landline phone and cell technology is not only the mobility offered by cell phones, but also the capacity of these phones to store and transmit data and pictures and even connect to the Internet. These characteristics are the keys to telematics and the application of wireless technologies in remote home care.

Cell phones are increasingly more powerful communication tools with Internet, computing, and photographic capabilities. They are currently defined as "smart phones" (Helal et al., 2008). As such, cell phones can become the carriers of health information, allowing patients to carry their entire medical history within their mobile cellular phone. As technology evolves, these phones will seamlessly connect with networks of computerized medical records, insurance data, and demographic indicators.

Waegemann (2008) identified seven needs or conditions for cellular phones to carry and transact health information:

- The need for a universal platform
- The need for connectivity of this platform with other telecommunication devices and systems
- The need for agreement and consensus on the data to be collected and exchanged
- The need for safety protocols to be established and maintained for the storage and exchange of such data
- The need for user friendliness of these phones, so that the intelligence is largely built into the device and its use is relatively uncomplicated, especially for the elderly and the incapacitated or physically challenged patients
- The need for acceptance of the technology and devices by all the stakeholders in the healthcare system. The benefits from such applications must therefore be known, measurable, and trusted by the stakeholders
- The need for a wide range of applications and connectivity software that would facilitate the ubiquitous implementation of these phones by providers and patients and would make implementation acceptable to private and public health insurers and payors

In this example, government telecommunication regulators can work together with health leaders in the Medicare and Medicaid branches of the federal government. There is a need to strive for uniformity and standardization in devices and carriers of telecommunication. Such initiatives have a better chance to succeed when they are actively supported by government agencies.

Another area in which government support would be crucial is the agreement on standardization and consensus on the data to be collected and its intended use. Public health leaders can and should act decisively to support legislation and regulations that promote consensus and standardization of what data would be included in a patient's profile, where such data would be stored, how such data would be shared, and who would have access to it so that HIPAA precautions are safeguarded.

These needs and conditions are the basic needs for the health information system that providers and insurers have been promoting for at least two decades. Issues of format, content, standardization, and security have been at the core of the effort to develop national health information networks. They also fully apply to the case of using cell phone technology in remote care and home care of underserved patients.

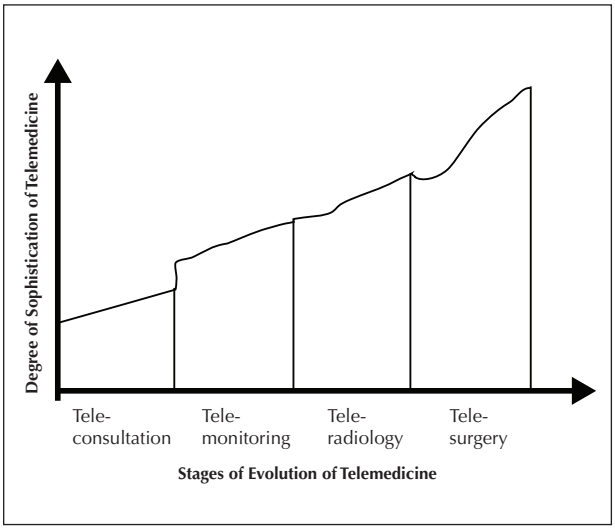
Another critical need, and also a major barrier to the implementation of cellular phones in telecare, is the issue of ownership of the health data to be centrally warehoused or even kept in a distributed format. Who owns the data? There is need for regulations and agreements on the nature of ownership as such large databases are collected and maintained, as well as when they change hands to various stakeholders.

The level of sophistication increases as uses and applications of telemetry and telemedicine become more intrusive in a patient's care. Figure 3 shows the evolution of telemedicine.

The figure shows four illustrative stages in the evolution of telemedicine, from teleconsultation to telesurgery. The more invasive the medical procedure (such as in surgery), the greater the sophistication of the wireless technologies necessary for such remote care. In August 2008 the Intel Corporation demonstrated at the company's forum in San Francisco a wireless electric power system. Such technology will be able to charge electric and electronic devices without the need for transformers and wall outlets. This innovation is a good example of the developments in wireless technologies that have immense applications in a range of remote care possibilities.

The quantum leaps in telecare shown in Figure 3 and the dramatic improvements in technological capabilities are contributing to a bright future for remote home care, especially for the underserved and rural populations who suffer from chronic diseases. Telemedicine and wireless technologies are without a doubt a promising way to provide accessible and affordable care to this highly vulnerable population. This is not only a medical emergency but also—from the government's perspective—a moral and ethical obligation for public health leaders to engage in promoting and funding such promising solutions as telemedicine and wireless applications of care.

Figure 3: Evolution of Telemedicine and Illustrative Stages



Facilitators to Implementation

As government leaders in the healthcare sector ponder the implementation of telemedicine for the care of the underserved patients with chronic diseases, we should consider several factors that may facilitate such implementation.

The first factor that may facilitate implementation is positive previous experience with telemetrics and telemonitoring in other industries. Telemetry has been successfully applied in the financial sector (e.g., electronic banking) and in transportation (e.g., GPS instruments for worldwide positioning). Technologies that entail wireless transmission of data are at the core of very useful systems in various economic sectors. This successful experience may serve to boost confidence in telemedicine, even when accounting for the legal, ethical, and human constraints of health information systems (Helal et al., 2008).

The second facilitating factor is the ever-ubiquitous use of cellular telephones by all socio-economic segments and age groups of society. This phenomenon clearly facilitates any application of medical care based on cellular technology. Health leaders need not be concerned with how patients will adopt or be exposed to such applications, because chances are high that they are already users of cellular telephones—regardless of their income, demographics, and/or social status.

Moreover, the ubiquitous use of cellular telephones by all segments of the population substantially reduces the need for specialized training in the use of smart phones. There is also the benefit of a low level of resistance (if any) to the use of smart phones in healthcare delivery to disadvantaged patients.

The acceptance of cellular technology and smart phones also extends to providers. Caregivers will be much more likely to use medical applications of wireless technology when they are well cognizant of the fact that their patients are well acquainted with such technology and can readily adopt wireless applications of medical care.

A third facilitating factor is the relatively low cost of set up and maintenance of such wireless systems. For the purpose of remote home care of chronic diseases, presently the technology requires the installa-

Facilitators to the Implementation of Telemedicine for Underserved Patients with Chronic Diseases

- Positive experience with prior successes of telemonitoring in other sectors.
- Ubiquitous usage of cellular phones and wireless technologies thus little need for training of users.
- Relatively low set-up and maintenance costs of the core systems.
- Relatively low level of intrusion of care, at least in the early stages of evolution of the technology.
- Support from government agencies: regulators, legislators, and payors (e.g., CMS, NIH, FDA, and CDC&P).

tion of a base at the hospital or clinic. Cellular telephones would need to be equipped with the software needed for the processing of clinical data from the patient.

The fourth facilitator is the relatively low level of intrusion of care, at least in the early stages of evolution of the wireless technology. By using cellular telephones to monitor clinical indicators of chronic diseases, caregivers are able to obtain critical data without resorting to visits to the hospital, multiple and perhaps unnecessary encounters, as well as sessions in which patients are questioned about their medical conditions. Much of the clinical information of interest to caregivers is already on file electronically in the base station at the hospital. Blevins (2008), for example, has written in *The Christian Science Monitor* that HIPAA permits healthcare providers to widely share clinical information about a patient without prior consent. By strengthening privacy laws, the use of cellular telephones will be enhanced. As clinical data flows from smart phones to the base station at the hospital, there is no further need to share such data with other entities that are not directly connected with the treatment and management of the chronic disease.

Furthermore, the current technology allows the base station at the hospital to translate individual patient data into an aggregate form of data about a given chronic disease and a category of patients—rather than sharing raw data of individual patients. This advantage of the system also allows another adherence to strict HIPAA regulations. The cellular telephones can be equipped with an electronic mechanism that codifies patient identity when transmitting data to the base unit at the hospital. Even when produced at the factory, the necessary software will allow the base unit to decipher the codified identification of individual patients. In this case, HIPAA regulations are a facilitator to cellular technology rather than a barrier.

The fifth facilitator is the support already in place, and the support we advocate and recommend in this report from government agencies in the healthcare sector: regulators, legislators, and payors. Government health leaders in agencies within the Department of Health and Human Services (Centers for Medicare & Medicaid Services, the National Institutes of Health, the Food and Drug Administration, and the Centers for Disease Control and Prevention) and the Department of Veterans Affairs will be particularly interested in wireless technology for the care of chronic diseases among the over 40 million Americans who are uninsured or underinsured. The more the leaders know about the benefits from this technology, the more they will support its wide implementation throughout the healthcare delivery system.

Legislators in Congress are also potential supporters of wireless technology and telemedicine. We emphasize their role in the next section on Recommendations to Public Health Leaders. Legislation supporting telemedicine should be directed towards facilitating the application of this technology across state lines, providing benefits to the wireless industry for the inclusion of clinically oriented programming into the original equipment of cellular telephones, and clarifying the impacts of legislation such as HIPAA on the management of clinical data of underserved patients with chronic diseases.

Thus, as the benefits to patients and the greater social good from wireless technology become more visible, legislators can help by codifying those variables that can further support widespread applications of telemedicine. There may not be a need for targeted legislation, but there may be a need to tailor state and federal regulations to a more viable environment for the implementation of telemedicine and wireless technology for the underserved.

Recommendations for Government Leaders and Public Health Agencies

The lessons learned from the review of the current state of telemedicine and health wireless technology are summarized in the following action recommendations for government health leaders.

Recommendation One: Support the Development of Telemedicine and Wireless Technologies

Support the development of telemedicine and wireless technologies by providing fiscal and financial incentives for telemedicine in the care of chronic diseases.

This recommendation calls for policies and actions by public agencies that actively support the use of telemedicine and wireless technologies in the management and monitoring of chronic diseases. Such clearly stated policies will greatly encourage hospitals and other caregivers to acquire and to implement solutions based on wireless technologies. As a major player in healthcare funding, government agencies have the ability to carry an influential voice in the directions that certain technologies and modes of care delivery will and should take by providers (Pontes et al., 2008).

Government agencies involved: To carry out this recommendation, the policies must be generated and supported by both the Congress and the executive branch of government. Specifically, the Department of Health and Human Services must spearhead the development of policies, in conjunction with the Department of Defense and the Department of Veterans Affairs. There is already a host of existing programs in this area in which government organizations have taken a leadership position. The policies and actions in this recommendation are designed

Action Recommendations for Government Leaders in Public Health Agencies

Recommendation One
Support the development of telemedicine and wireless technologies by providing fiscal and financial incentives for telemedicine in the care of chronic diseases.

Recommendation Two
Establish programs to support underserved chronic disease patients in the use of telemedicine and wireless technology in remote care.

Recommendation Three
Develop specific programs with budgetary commitments and workable incentives for health providers and the medical industry who are engaged in telemedicine and the use of wireless technologies in the management of chronic diseases.

Recommendation Four
Establish projects to measure success and benefits from telemedicine and wireless in the care of chronic diseases.

Recommendation Five
Establish collaborative arrangements for research, stimulus funding incentives, and cooperative projects with chronic disease organizations such as diabetes, asthma, cardiovascular, and cancer institutes for the promotion of telemedicine and wireless technologies on solutions to the management of these diseases, including public relations efforts to raise awareness of the importance and benefits of these technologies.

specifically to target telemedicine and wireless technologies in the management of chronic diseases.

Recommendation Two: Establish Programs to Support Underserved Chronic Disease Patients in the Use of Wireless Technologies

Establish programs to support underserved chronic disease patients in the use of telemedicine and wireless technology in remote care.

The focus of such programs is the large segment of patients who are underserved in urban and rural populations. The programs will also set guidelines and priorities that public health leaders consider to be essential to the public good. Telemedicine and wireless technologies offer a window of opportunity to make considerable strides in the management of chronic diseases and the provision of care to the underserved segments of the population.

These programs will include targeted funding grants to healthcare delivery organizations in the private and public sectors, and the sharing of knowledge and metrics about the underserved patients with chronic diseases. Some programs will be managed by government agencies, and others will be supported by the government but run by private organizations.

Government agencies involved: At the operational levels, the programs in this recommendation should be undertaken by federal and state agencies, down to the level of the county or even municipal government. The U.S. Department of Health and Human Services should increase its collaboration with regional and state health agencies such as the Appalachian Regional Commission and state health offices. This cooperation will allow the public agencies a better access to the local populations of underserved patients with chronic diseases. In urban areas the city health commissioners are an excellent source for cooperation with state and federal programs because they have routine and direct contacts with these patients.

Such programs would be candidates for the agenda of the Joint Working Group on Telehealth (JWGT). This interagency group could expand its scope of activities in funding and education to target chronic diseases and the underserved population. Examples of these programs include funding demonstration projects for the use of wireless technology to increase access of care to underserved patients with chronic diseases.

Recommendation Three: Develop Specific Programs with Budgeting Commitments and Workable Incentives

Develop specific programs with budgetary commitments and workable incentives for health providers and the medical industry who are engaged in telemedicine and the use of wireless technologies in the management of chronic diseases.

This recommendation calls for programs that offer incentives to the *private* sector in healthcare delivery to increase the use of telemedicine and wireless technologies in the management of chronic diseases. We have learned that hospitals are open to implementation of telemedicine and remote care if such technologies can be shown to produce tangible benefits. Government-led programs that offer incentives to private healthcare delivery organizations to incorporate new technologies can be very effective in stimulating private initiatives. The targeting of underserved patients with chronic diseases creates a specific focus for the application of public incentives for the private sector. This allows for an effective assessment of funds expended and outcomes achieved.

Government agencies involved: The Centers for Medicare & Medicaid Services (CMS) within the U.S. Department of Health and Human Services should take the lead in these types of programs. As the federal agency that administers Medicare, Medicaid, and the State Children's Health Insurance Program, the CMS is very interested in the application of technologies to care, so that savings can be attained, access improved, and quality maintained. The CMS is therefore in a good position to support the private sector with incentives targeted to wireless technologies as they apply to the care of chronic diseases in underserved patients. Considering the immense burden of the cost of chronic diseases on the federal and state budgets, even minor successes with such programs will be highly welcome by the CMS.

Recommendation Four: Establish Projects to Measure Successes and Benefits

Establish projects to measure successes and benefits from telemedicine and wireless in the care of chronic diseases.

It is not enough to have a literature that demonstrates, largely anecdotally, that telemedicine and wireless technology indeed provide beneficial contributions to the care of chronic diseases in underserved populations. There is a need to systematically study the benefits accrued from telemedicine and wireless technology. The results from these studies will reinforce the basis for government policies and will contribute to a more robust and accountable system for the allocation of public funds for these programs.

But the measures of success are more than data to support public funding. These measures also provide standards for evaluation and monitoring of programs, such that public agencies can redirect, reframe, and restructure or terminate projects and programs.

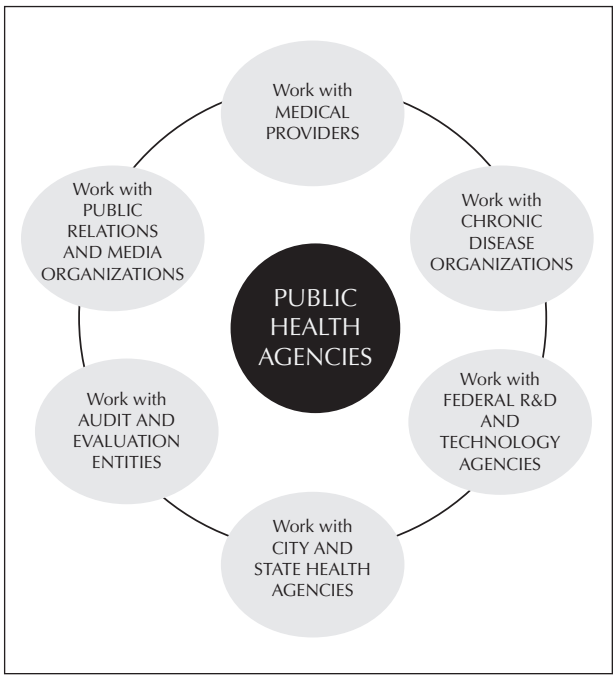
Government agencies involved: The Agency for Health Care Research and Quality (AHRQ) in the U.S. Department of Health and Human Services (HHS), in cooperation with the National Science Foundation (NSF), should be the lead federal agency in measuring success of telemedicine and wireless technology. Evaluation studies should also be conducted as a cooperative endeavor between the federal research organizations (AHRQ and NSF) and research institutions in the health care industry—specifically, in collaboration with the American Medical Association (AMA), the Joint Commission on Accreditation of Healthcare Organizations, the American Hospital Association, and the Healthcare Information and Management Systems Society (HIMSS), among others.

Recommendation Five: Establish Collaborative Arrangements

Establish collaborative arrangements for research, stimulus funding incentives, and cooperative projects with chronic disease organizations (such as diabetes, asthma, cardiovascular and cancer institutes) for the promotion of telemedicine and wireless technologies as solutions to the management of these diseases, including public relations effort to raise awareness to the importance and benefits of these technologies.

Managers in public health agencies at the federal, state, and local levels need to closely work with the influential organizations that are dedicated to chronic diseases. These include associations, foundations, and societies for diabetes, asthma, Alzheimer's, cardiopulmonary diseases, cancer, and arthritis. These organizations already have a host of projects and well-oiled machinery, which is employed effectively in working with Congress and the public. By creating joint projects with these organizations, government agencies will be able to enhance their own initiatives and avoid duplication of effort. Figure 4 illustrates the web of these collaborations.

Figure 4: Action Relations of Public Health Agencies with Related Organizations



Collaboration with these dedicated institutions will also allow government agencies to more efficiently interact with large groups of patients who suffer from the specific chronic disease and of which the dedicated organization maintains an updated knowledge base. The focus of the government agencies is the umbrella concern for the chronic disease patients—cutting across the various diseases, thus serving as an integrative magnet for the diversified effort of so many groups and organizations.

Government agencies involved: Collaboration with the dedicated organizations listed above should be undertaken by the government agencies discussed in Recommendations Two and Three. For example, the Agency for Healthcare Research and Quality and the National Institutes of Health could find research projects by universities and industry, all in conjunction with the effort already underway by, for instance, the National Cancer Institute and the American Diabetes Association—but with a special focus on the use of wireless technology in the care of cancer and diabetes in the underserved population of patients.

In addition to research, specific programs designed to implement wireless technology should also be fostered in cooperation with industry and dedicated organizations such as the American Lung Association and the American Diabetes Association. Appendix II describes a cooperative project in the use of wireless technology in the management of diabetes. The collaboration between a private company, a university, and a large urban hospital has produced a promising implementation of a wireless monitoring system for home care of underserved patients with diabetes.

Appendix I: Telemedicine and Wireless Technologies in Reforming Healthcare Delivery

The complexity of healthcare delivery has been a constant barrier to past attempts to reform this system. Overall restructuring of the system that includes providers, regulators, insurers, and industrial companies making equipment, technology, and pharmaceuticals has been proven to be an impossible task (National Health Policy Conference, 2009). Recognizing the magnitude of this endeavor, the Obama Administration is approaching the problem in an incremental mode, anchored in a major effort to reduce the costs of healthcare delivery and to ensure "access to affordable, quality, and portable health insurance" for all Americans (Barack Obama Health, 2008).

The key elements of this plan for reforming health care in American are:

- Providing coverage for all Americans
- Modernizing the healthcare delivery system
- Promoting prevention and the strengthening of public health

The plan to modernize the system is of particular interest to the topic of this report because it is anchored in a massive investment in health information technologies. Although the original plan called for investing primarily in electronic health records systems, there is a growing consensus in the Administration that other technology such as wireless technologies will also be addressed by the plan to reform the healthcare delivery system.

Health Technology and the Underserved

The confluence of the use of information and other technologies and coverage for all Americans (including the underinsured, non-insured, and underserved) in the Obama Administration's plan for reforming healthcare delivery provides strong support for the set of recommendations advanced in the previous section of this report. The Obama plan calls for the commitment of necessary resources and the inclusion of patients in rural and underserved populations.

Focusing on the use of wireless technology in the management and monitoring of chronic diseases for the underserved is a major step in the direction proposed by the Administration's plan for reforming health care. Chronic diseases are a major cost burden. With the implementation of wireless technologies and remote care there is an excellent opportunity to accomplish cost savings and the provision of health services to rural and underserved patients.

Federal agencies will be asked to implement various parts of this plan for reforming the healthcare system. The use of wireless technologies and the fostering of telemedicine and remote care offer a unique opportunity to implement proven, less expensive, and much less complicated technologies in an effort to cut the cost of healthcare delivery. For example, computerized medical records offer relatively inexpensive and simple technologies designed to accomplish improved access to quality care for underserved patients and to engender improvements in the management of chronic diseases (Prentice and Flores, 2006).

The recommendations offered in this report are a good fit with the aims and proposed activities of the Obama Administration's plan to reform healthcare delivery. With the establishment of the White House Office of Health Reform there is a clear push to

increase the engagement of federal agencies in the implementation of the reform initiative.

This report advanced recommendations for inexpensive and highly promising technologies for improved access, better management and monitoring of chronic diseases, and the ability to show tangible benefits within relatively short time periods. Hence, the use of telemedicine and wireless technologies for chronic diseases could become the spearhead for the application of information and other technologies in reforming healthcare delivery in America (Anderson, Herbert, Zeffirs, and Johnson, 2004).

Appendix II: Case Study of the Use of Wireless Technology

Recognizing the crisis in healthcare and the role that technology plays in providing some attractive solutions, we focus in this example on the possibilities of applying wireless technology to facilitate the monitoring of patients with the chronic disease of diabetes within an inner city population. We report on the complex effort of bringing together three crucial components: technology applications, an urban population of underserved patients, and patients with diabetes.

This appendix describes the study of the implementation of wireless technology in an urban, trauma-center general hospital. This feasibility study was conducted in 2008, and its purpose was to bring together industry, academia, and a medical center to implement wireless technology in the monitoring of diabetes in an underserved population. The study is now underway.

The Case of Diabetes

In this study the focus is on the case of the chronic disease of diabetes. The statistics are indeed alarming. Diabetes is a group of diseases characterized by high levels of blood glucose resulting from defects in the production of insulin.

There are three major types of diabetes.

Type 1 diabetes, also called juvenile-onset diabetes, develops usually in children and young adults when the body's own immune system destroys the pancreatic cells that produce the hormone insulin.

Type 2 diabetes, also known as adult-onset diabetes, generally starts as insulin resistance. As the need for insulin increases in the body, the pancreas tends to lose its capability to produce the hormone. Type 2 diabetes accounts for over 90 percent of all diagnosed cases and is generally associated with old age, family history, obesity, physical inactivity, and race or ethnicity. High risk populations in the United States are African Americans, Hispanic Americans, and Native Americans—all with high representation in the disadvantaged and underserved segments of the general population.

Gestational diabetes afflicts women during pregnancy and is characterized by glucose intolerance. Following pregnancy, almost 10 percent of women with gestational diabetes are diagnosed with type 2 diabetes, whereas women who have suffered from gestational diabetes are prone to developing the disease. About 20–50 percent of these women develop type 2 diabetes in the five to 10 years after pregnancy, and almost 70 percent of women previously diagnosed with gestational diabetes will develop type 2 diabetes during their lifetime (National Institute of Diabetes and Digestive and Kidney Diseases, 2005).

The projections for a worldwide rise in the number of people with diabetes are alarming. In 2000, 110 million people had diabetes. It is estimated that by 2010, there will be 220 million people with the disease and by 2025, the number will increase to 280 million.

Figure II–1 shows the estimated number of new cases of diagnosed diabetes in adult patients. Almost one in 10 people over age 20 has diabetes, and one of every five people over age 60 has the disease.

The distribution of people diagnosed with diabetes by race or ethnicity is even more revealing. In the African American group, 13.5 percent of those over

20 years of age have diabetes. Almost 10 percent of Hispanic Americans over the age of 20 have diabetes, and almost 13 percent of Native Americans over age 20 have the disease.

Defining the Problem

How can technology contribute to the management of diabetes in the underserved, urban, and disadvantaged population afflicted with the disease? How can technology help to monitor, via remote care, the condition of these patients with diabetes so that better access to care, improved quality of care, and more efficient delivery of care can be achieved?

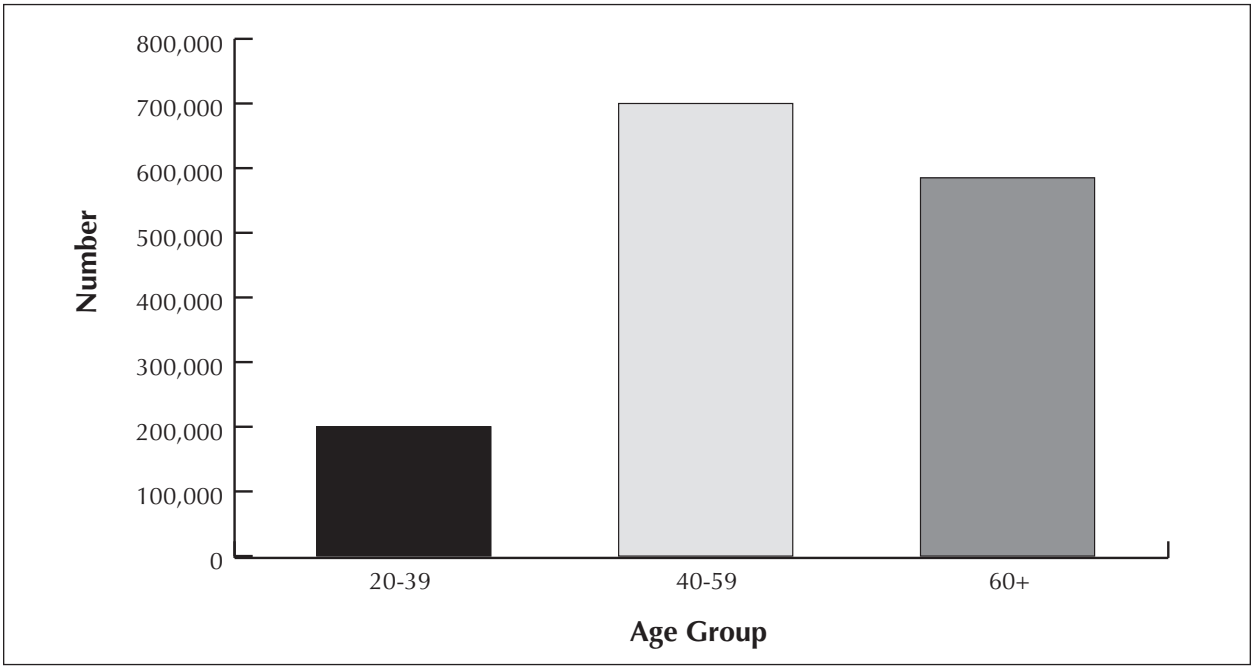
How Can Wireless Help?

Chronic diseases such as diabetes, if detected early, can be contained and patients can continue to lead full and high-quality lives. If the disease is not well managed, patients may develop more complicated health problems. Critical to effective management of a chronic disease are regular monitoring and an informed patient who takes responsibility for managing his wellness.

Medical science has made revolutionary changes in the past few decades. However, healthcare delivery organizations have made, at best, incremental changes. The growing discrepancy between the revolution in medicine and the minimal changes in healthcare processes is leading to inefficient delivery and is one of the most, if not the most, significant contributors to the exponentially increasing costs. Thus, the application of mobile technologies to health care, "m-health," appears to have the potential to effect substantial changes in the efficiency of healthcare delivery. The use of m-health solutions includes the application of wireless technology by providing hospitals with ways to achieve remote monitoring and control of patients within a standardized mobile Internet (wireless) environment. Integral to this successful application is the ability of the hospital to build on its existing infrastructure. In Figure II–2 we show a standardized wireless environment. This model is the framework used by the Canadian company INET, with which we conducted this study.

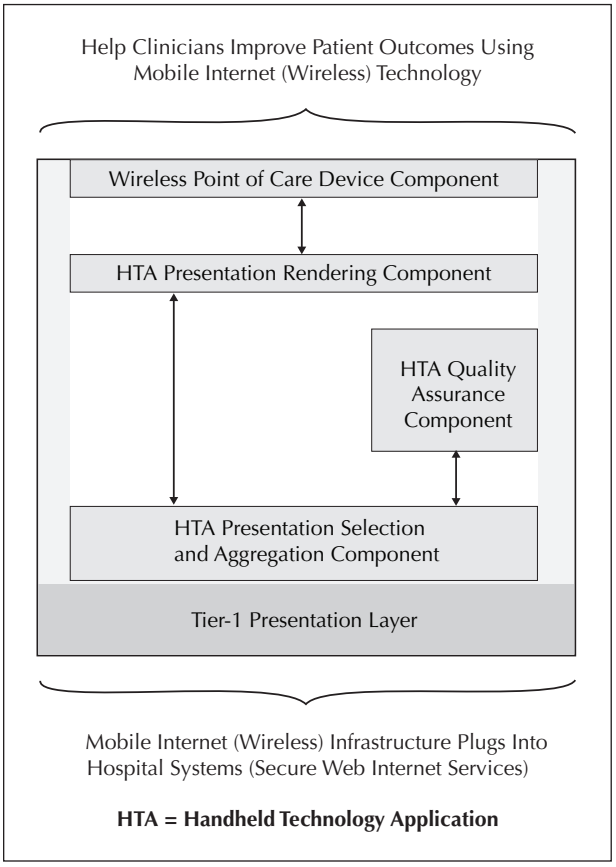
Wireless technology has the ability to connect healthcare providers (physicians and nurses) with each other, with hospital administrators, and with patients. The technology is part of the much-publicized electronic health environment, "e-health." The application of communication via hand-held

Figure II–1: Estimated Number of New Cases of Diagnosed Diabetes in People Aged 20 Years or Older, by Age Group—United States, 2005



Source: *2001-2003 National Health Interview Survey estimates projected to year 2005.*

Figure II–2: A Standardized Mobile Internet (Wireless) Application



devices, cellular technology, and the Internet endows healthcare providers with outstanding capabilities to monitor and to interface across distances, all with clarity and at a very affordable cost.

In monitoring diabetic patients, wireless technology provides the benefits of telemedicine by which patients can be monitored and observed, and their medical condition managed anytime and anyplace. This means that patients can be monitored from the hospital whether they are at home, at work, or anywhere else outside the hospital.

The INET Solution

INET is a technology company in Ontario, Canada. The company has developed a workable system which connects handheld devices to a stationary center, and which allows for the transfer of medical data. This system provides the medical provider with the capability to interface with patients by their use of a cellular telephone.

The technology proved to be very useful in the distance monitoring of diabetes. There are many communication and information exchange bottlenecks between patients and their physicians that prevent the effective treatment of the disease. The fundamental problem seems to be the ability to have a private and secure way to manage, search, and retrieve information at the point-of-care. In the case of diabetes, providers cannot quickly and easily respond to patients with high glucose levels when these patients are out of the hospital and out of reach of traditional methods of contact between them and their care providers. The care providers need to wait for patients to come to their office or hospital, respond to phone calls, reply using mail delivery, or never receive the information.

The INET solution is anchored in the use of a specially-equipped cell phone and the installation of a secure wireless application that allows patients to monitor glucose levels and to immediately transfer the data to their care provider. The physician or nurse uses a handheld device such as a PDA (Personal Digital Assistant) which is connected to a wireless network to confidentially access, evaluate, and act on the patient's data.

The INET solution calls for the patient (or family member) to enter the reading from the glucose monitor into the special cell phone. This requires the ability to read the data from the monitor and to input the numbers into the cell phone. In the past, INET considered the possibility of the direct reading of the glucose monitor into the special cell phone by utilizing Bluetooth technology. However, the company soon discovered that this significantly limited the pervasiveness of the technology.

For example, there are very few glucose monitors with embedded Bluetooth technology, and the Java implementation software on the cell phone varies widely among manufacturers. Thus, the likelihood of having a patient with a cell phone that has the right Java implementation with Bluetooth technology and a glucose monitor with Bluetooth capability is very unlikely. A study was conducted in Canada by a medical research organization to test this possibility of direct transfer from the glucose monitor to the special cell phone. The results show that this approach is very expensive and has limited success. The technology cost was about $2,000 per patient. In addition,

there was a need to conduct individual training sessions with a high level of ongoing support. In another study of monitoring hypertension, the Bluetooth approach was also considered infeasible and expensive relative to the INET-type approach.

The important issue to remember is that the INET approach is based on using cell phone technology that the patient is already using and is thus quite familiar with its features. The only change is adding a bookmark to the cell phone at no additional cost (except for the small fee of about $5 per cell phone per month for data transmission). There is also no need for additional training. The patient uses a simple step-by-step instruction sheet. After installation, the patients typically need no, or very little, ongoing technical support. The INET experience in Canada, with pilot projects of 45 patients, had only four calls for support in the entire set of projects, each of which necessitated only about five minutes to complete to the satisfaction of the patient.

In the population targeted in our study in the urban setting, the underserved patients are literate in terms of reading their blood levels and inserting them into the cell phone. Previous pilot studies have shown that there are very few mistakes in entering the readings into the phones, and that there is a good likelihood that the medical staff at the hospital will spot these errors and act on them.

A technology similar to that of INET in the monitoring of diabetes is used in the Netherlands to monitor newborn babies. Ronald Spanjers and Anne Rutkowski of Tilburg University have reported the pilot practices of such telehealth/telecare in the Netherlands. Cameras monitor newborn babies at the hospital and send the pictures to the parents' cell phone. This Baby Mobile technology is the transmission of what is called Virtual Baby Visit. Parents can monitor and see their newborn babies anytime and anywhere through their cell phones.

Implementing Wireless Technology

Armed with the knowledge that diabetes is rapidly growing at alarming rates in the urban underserved population and the successful application of the INET system, we decided to apply this solution in a sample of patients in an urban society. We chose to work with a major urban and trauma center hospital of about 600 beds. The hospital serves a population composed primarily of African American and Hispanic American patients. The vast majority are uninsured or severely underinsured. The hospital also has a growing number of patients with types 1 and 2 diabetes.

The Current Process of Monitoring Diabetes

We identified the problems inherent in the current process of monitoring diabetes patients at the hospital and the flaws in the record-keeping system of data on blood glucose levels.

The current management of diabetes patients in the population served by the hospital has several debilitating flaws. First, the patients and their families, who are responsible for making their daily measurements of blood glucose levels, are largely health illiterate. These record-keeping skills are, at best, incomplete, scant, and perilously sporadic. Patients are also generally at a social and economic disadvantage and are uninsured or underinsured. Over 75 percent of these patients rely on Medicare and Medicaid. Most of them use the emergency department of the hospital and its outreach clinics as their primary care outlets.

The Proposed Wireless Alternative

In discussions with the hospital and INET, it became apparent to us that a wireless alternative to the current communication problems between the hospital

The Problem of the Existing System of Monitoring Diabetic Patients

- Patients are required to enter daily readings into a log book
- Patients are largely health illiterate
- Patients neglect, forget, and misconstrue entries in logbook
- Patients often forget to bring their logbook to hospital visits
- Patients are largely poor elderly, uneducated—hence unable—to keep adequate records and to consistently or effectively monitor their disease

and its diabetic patient could be a major improvement. The hospital in Chicago is about 50 percent larger in size than the Canadian hospital where INET conducted its exploratory program in 2006. The Chicago hospital also has about 3,000 new referrals of diabetic patients per year.

However, the population served by the Canadian hospital was much more affluent and literate than the inner city population served by the Chicago hospital. This posed an added problem of education, training, and adaptation of the wireless technology to the Chicago sample of patients.

The proposed wireless alternative experiment to manual record keeping and communication consisted of five steps:

1. Identifying a sample of 5–10 patients
2. Providing the patients with specially equipped cellular phones
3. Training and instructing the patients on the use of the cellular phones to record and transmit their daily readings of their blood glucose levels
4. Establishing a central unit at the hospital where all wireless electronic messages would be received and analyzed by the medical staff for further action. The medical staff would be trained by INET
5. Conducting the experiential project to test the feasibility of the wireless solution in the urban sample of diabetic patients

Expected Outcomes

Based in part on the results from the Canadian experiment, we expect this ongoing project to yield several positive outcomes. The literature on the medical management of diabetes has shown that there are clinical and economic benefits that accrue from telemedicine/telecare and from improvements in the process of communication between caregivers and patients.

We consider our sample of disadvantaged patients to offer particularly promising opportunities for measurable benefits. If patients adequately learn to use the cellular phone to transmit their daily glycemic readings, we will overcome the basic flaws in the current communication process. Moreover, the cellular technology is relatively simple to adopt and inexpensive to install and to use.

The vast majority of our target population of inner city patients already use cellular phones in their daily wireless communication patterns. What is now required is a simple procedure of recording and sending data which they or their family members already collect and transcribe—albeit now in an imperfect and ineffective manner. The wireless technology is *embedded in the cellular phone*, so there is no need for the patient to gain understanding of its mechanism in order to effectively use the device (Parker, 2006).

We expect that the outcomes from the initial sample of patients will save about $2,000 per patient per year in terms of cost and time of both patient and caregivers. Much of the savings in time is credited to the radical reduction in time spent by caregivers in their attempt to reconstruct important, missing, or even wrong glycemic readings and recordkeeping in the logbooks. Additional savings are counted in the time it currently takes to keep records at the hospital.

We expect the clinical outcomes to be even more impressive. Based on the British PDS (Prospective Diabetes Study), we computed the potential benefits for the initial sample of five patients to be of at least two kinds. First, it reduced the burden of hospitalization due to uncontrolled changes in glycemic levels.

Secondly, diabetes type 2 is a progressive disease requiring intensive monitoring. In the disadvantaged population of our project, even if we maintain the current monitoring process of logbooks, there will be deterioration in the control of blood glucose levels and an increase in clinical complications such as eye disease, kidney damage, and loss of limbs. We therefore integrated the British PDS results of reduced risk of complication by at least 25 percent. Thus, adding this benefit to reduced hospitalization, we project 25 percent less morbidity and mortality. Within twelve months of the implementation of the wireless solution, one patient in the sample who might have died will still be alive, and one patient, at least, who might have been hospitalized will be spared emergency hospitalization. A third patient in

the sample of five will be spared a major debilitating complication such as loss of vision or, perhaps, amputation of a lower extremity.

Lessons Learned

Although the project described in this Appendix is not yet completed, we have learned the following lessons:

- Based on the Canadian experience and the first phase of the American project, we learned that the complex array of organizations involved requires lengthy preparatory effort in order to bring all the parties on board.
- We learned that simple solutions such as cell phone technology and the use of wireless in the monitoring of diabetes can be a very effective mode of providing remote care *and* creating cost savings. Diabetes patients who are remotely monitored via cellular technology make fewer visits to the hospital. This technology also makes it easier for family members and caregivers to manage the patients and the disease. Early detection helps to reduce morbidity and mortality.
- We also learned that this technology is instrumental in extending remote care to underserved patients, thus replacing the need for emergency room solutions.

The case study presented in this Appendix could serve as an example of barriers and facilitators of technology implementation for any planned government effort to employ technology in the reforming of the nation's health care delivery system.

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