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Chapter 1

Telemedicine and Health Care

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THE RAPID EXPANSION of information technology and its applications in almost all aspects of modern society including commerce, industry, banking, education, entertainment, as well as health care mirrors the general expansion of the information age and the development and deployment of the so-called "information highway." It has created enormous opportunities for development in terms of improved efficiency, effectiveness, and productivity, and has provided unprecedented public and professional access to information and various sources of help dealing with a wide range of health and health-related issues. At the same time, it has produced several serious problems that must be addressed through voluntary and regulatory action. These problems include quality control, consumer protection and security, interoperability between systems, harmonization (universal standards), social equity, intellectual property rights, and investment strategies.

THE EVOLUTION OF TELEMEDICINE

The seemingly intransigent problems of increasing cost and inequitable access to quality health care, coupled with the merger of the information technology and health services sectors gave rise to the field of telemedicine. In broad terms, since its inception in the late 1960s and early 1970s, the history of telemedicine can be characterized as consisting of three major periods or eras. Each era has been closely linked to or derived from significant advances in associated information technology, telecommunications, and computers.

First was the telecommunications era, which spanned the 1970s and continued into the early 1980s. This era depended on broadcast and television technologies, which comprised complex, cumbersome, and often unreliable communication systems. In this era, with the exception of a few and very costly systems, audio and visual data were not fully integrated. The second or digital era emerged next in the late 1980s and continues. Digitization in telecommunications and computer advances mark the advent of this era. The integration of telecommunications and computer processing coupled with transmission of relatively large amounts of information on limited bandwidth has characterized this era. The Integrated Service Digital Network (ISDN) technology, which permits simultaneous transmission of voice, video, and biometrics data at relatively high speeds within a "universal" network, was the foundation. Telephone lines and sophisticated switches enabled point-to-point, point-to-multipoint, or multipoint-to-multipoint connections, the latter within designated networks.

In the continuing development of electronic communication technology, the digital era in telemedicine is now being challenged and, in many instances, succeeded by the third, or Internet era. This era uses the Internet, that complex, powerful, and ubiquitous communications "network of networks." The Internet allows open access to a global-communication environment. It constitutes a radical departure from the preceding eras in that the technology is less expensive, more ubiquitous and, therefore, more accessible to greater numbers of people. Extensive image, audio, and text information can be stored and retrieved at points of care and consultation through this technology. Internet services in health care (e-health)

range from posted information about health issues and health resources, support groups and lay referral to the provision of professional services, including diagnosis, treatment, and drug prescriptions.

The inception of and interest in the Internet era of telemedicine derive, at least in part, from frustrations of telemedicine users with the inability to provide accurate and timely information at an affordable price using legacy systems.[a] However, problems with the Internet for telemedicine have already created considerable interest in the incipient era of the federally sponsored Next Generation Internet (NGI) or Internet 2 (I2) developed in the private sector. Because of its widespread distribution and popularity, access to the original Internet is often delayed or denied at peak use periods, although the predicted massive failures have not occurred. Also, limited bandwidth precludes storage and transmission of large data sets required for certain diagnostic and/or clinical applications. Other problems pertain to security, latency, synchronization, and quality of service.

The promise of NGI/I2 lies in the estimated 100/1000-fold increase in bandwidth and increased rate of information transfer. Federally and privately funded research initiatives in developing the infrastructure and test-beds for NGI/I2-based telemedicine are underway. However, even before the NGI/I2 experiments have been completed, the U.S. Department of Defense has initiated research and development of Intelligent Integration of Information (I*3) by the Defense Advanced Research Projects Agency (DARPA).

The I*3 is essentially a data management reconfiguration. Its goal is to expand data acquisition and integration capabilities, and to couple these with enhanced human-computer interaction and collaboration between analysts and decision makers. I*3 has been labeled by some as an enhanced "information food chain." While this development is taking place in the United States, public and private sectors in the European Community are cooperating in the development of Intelligent Information Interfaces (i3) directed toward moving computing power from the desktop and embedding it in everyday objects. The goal is to develop vertically and laterally "connected communities."

Ultimately, both i3 and I*3 may have large incremental impacts on the capability and distribution of electronic communication, and these developments must also be taken into account in this initiative. Regardless of improvements and innovations in technology, traditional problems of access or ubiquity, availability,[b] quality of service,[c] and security[d] remain.

THE RATIONALE FOR TELEMEDICINE

Logic dictates, and telemedicine advocates believe, that the appropriate use of telemedicine can redress the intransigent problems of constraints on access to care for large segments in the population, continuing health care cost inflation, and uneven geographic distribution of quality. Indeed, the pursuit of telemedicine is fueled by the fact that despite decades of other notable national and international efforts and programs:

- Access to health care, if anything, may have diminished for certain disadvantaged groups in many countries, including Europe and the United States.
- Cost inflation in health care has not abated.
- The gap in medical care between developed, emerging and re-emerging countries has widened in some respects.
- And, geographic variations in quality of care within and between countries have not diminished.

[a]Legacy systems are systems that use telephone lines with integrated switching devices. The legacy system does not permit alternative information packet routes and, therefore, information transfer may be interrupted and/or lost.

[b]Availability has been defined as the likelihood that a network is available for service and functioning properly.

[c]With regard to technology, Quality of Service (QoS) has been referred to as the capability of a network to provide a range of guarantees about its performance, measured in terms of sustained bandwidth, latency, and/or packet loss rates.

[d]Security refers to the capability of a network to ensure the confidentiality and integrity of information transmitted across it.

What then is the promise of telemedicine? How can we expect telemedicine to resolve these seemingly intractable and intransigent problems? What does telemedicine have to offer that was previously unavailable to enhance access, contain cost, and improve quality of health care? The basic assumptions and logic underlying the potential contribution of telemedicine in each of these are presented briefly below.

Accessibility enhancement

The potential and realized effect of telemedicine on access to care is most direct and measurable. In fact, to date the presumed increase in access to care for remote populations has been the cornerstone of telemedicine development. In all likelihood, its future is much greater in scope and application. Be that as it may, by virtue of its distributive capacity, telemedicine can obviate or reduce most travel distance, travel time, and some appointment delay to care. In theory, other things being equal, access to both specialty and primary care would be available regardless of the relative location of the patient. Thus, the need among patients to travel for specialty care, especially diagnosis, would diminish. The more remote and the farther away people live from medical care centers the more they can profit from this system.

Cost containment

Ironically, technology is a major culprit in the rising cost of care. Technological advances in testing, diagnosis, and treatment have produced significant improvements in health, not however, without increased cost. Telemedicine technology may be different. It can contain cost inflation by providing appropriate care to remote patients in their home communities. This care would be rendered at local health facilities by local health providers, but with ready access to and, when necessary, can work under the direct supervision of remote consulting specialists. This is likely to diminish the need for transporting certain patients to tertiary care centers; or, alternatively, reduce the need for specialists to travel to remote locations without compromising the quality of care patients receive. The cost of care at local facilities is likely to be less than that at tertiary care centers. Moreover, because of the ready availability of extensive information about patients in electronic form and reliance on efficient information technology, unnecessary replication of diagnostic tests, and the intensity of care or, in some cases, "over treatment" can be reduced. At the same time, efficiency and coordination of care may be enhanced.

Quality improvement

Views regarding the anticipated effects of telemedicine on quality of care are not as direct as those of access and cost containment. Nonetheless, the basic premise is that telemedicine would promote coordination and continuity of care by virtue of the ready availability of comprehensive information on the patient regardless of site of care. Additionally, telemedicine accords remote providers unique opportunities for targeted and highly effective continuing medical education, diminished isolation, and ongoing interactions with specialist colleagues from tertiary care centers. Finally, the technology can serve as a highly effective tool for clinical decision support for all providers, thereby reducing "medical errors."

While there are no reliable estimates for total U.S. investment in telemedicine, the American Telemedicine Association estimated federal (both military and civilian) expenditures on telemedicine in 1999 at about $240 million. This estimate does not include Medicare expenditures on teleradiology or patient monitoring. The total federal expenditures in the United States over the past 5 years could well have exceeded $1 billion. It is appropriate, therefore, to make a critical assessment of the status of this field and where it is going. A valid assessment of this field is neither simple nor straightforward, however. One problem is that we have yet to reach authoritative consensus on a clear and precise definition of telemedicine content and boundaries, that is, what it is and what it is not. And, although ultimately telemedicine may be fully integrated into the mainstream health care system, we have not resolved the interim question of whether

telemedicine constitutes a new system of care or whether it is simpy an electronic adjunct to clinical practice and the dissemination of health information. Additionally, we are faced with continual and often dramatic changes in information technology that significantly alter the production process of health and health care. In turn, these changes alter the assessment matrix and the ultimate cost-benefit ratios of telemedicine.

This reality and potential, coupled with the continuing expansion of e-communication and its direct linkage to the development and expansion of telemedicine, require that, periodically, it is prudent and necessary to "step back" and take stock of telemedicine developments, problems, and prospects. Furthermore, it is necessary to make appropriate and timely recommendations based on these observations, and to develop appropriate research and actions agendas to support the future development and deployment of telemedicine.

Such assessments must include and integrate developments in each of the inclusive telemedicine sectors. While specific and individual sector reviews and critiques are useful, these efforts should be presented in a forum with participants from all major sectors. In this manner, the developments, problems and prospects from one sector are compared and contrasted to those in other sectors. What emerge, therefore, are common perspectives and integrated analytic schemes to help future development.

A VIEW TO THE FUTURE

Optimism about the future of telemedicine must be tempered with concern. It is important, for example, to note that this is not the first generation of telemedicine. As discussed earlier, the first generation appeared in the late 1960s and early 1970s—and lasted less than a decade. The reasons for the demise are numerous and include the following:

- Cumbersome, unreliable, and expensive technology.
- Short-term funding for research and development.
- Unrealistic expectations for short-term performance and evidence.
- Perhaps not surprisingly, lack of recognition and limited acceptance by mainstream medicine.

In many respects, the current situation of the second generation of telemedicine is substantially different from the first. Today, every state in the United States and almost every country in the world has some telemedicine activity and experience. The technology has taken giant strides in increasing functionality and restraining cost. Indeed, the current and rapidly expanding telemedicine and telematics technology was only a futuristic dream during the first generation of telemedicine.

Accelerated developments in bioinformatics, miniaturization, and computer chip design promise major advances in the prevention, diagnosis, and treatment of disease and the promotion of health and well-being. In addition, on the horizon are continued developments in genomics, miniaturization, artificial intelligence, and chip design. Some may question whether this is telemedicine, telehealth, e-health, health informatics, or biohealth informatics. It does not really matter what we call it or where we draw boundaries. The ultimate quest is to cure disease, prevent it if possible, reduce infirmity, and enhance the quality of life. Collective and collaborative efforts from various fields of science and technology, including what we now call telemedicine, are necessary.

While much is different today, there are some disturbing similarities with the past. Despite the widespread proliferation of telemedicine projects and programs, few would claim that the promise of telemedicine has been fully realized or that the research to date has confirmed claims made by advocates and supporters. This second generation of telemedicine faces some of the same uncertainties faced by the first generation:

- Many projects have been funded for the short term, and are based on incomplete or nonexistent plans for long-term sustainability.
- The lack of mature telemedicine programs prevents adequate and definitive cost-benefit analysis, particularly in terms of health outcomes, patient-borne costs, and total costs.
- With certain exceptions, such as teleradiol-

ogy and telepathology, and except for curiosity and lip service, health providers and health administrators have not embraced telemedicine enthusiastically. Few think of it as a possible integral component of the health care delivery system.
- The success and progress of telemedicine are being met, in the United States at least, by state-based protectionism, and inconsistent federal policies and financing regulations. Internationally, major challenges have yet to be overcome, including legal, ethical, economic, cultural and logistical issues.

At the same time, the technology has developed a life of its own that continues at an accelerated pace, the current setbacks in "dot-com" businesses notwithstanding. In fact, the current decline in "dot-com" business will result in an appropriate sorting and sifting, and a reality check. Market forces have created winners and losers. Perhaps, this is as it should be.

Information technology has permeated every aspect and every sector of society, including health care. The only questions we should raise about the future is how to position our health care institutions, ourselves, and our patients to maximize the benefits and minimize the drawbacks of this powerful tool.

Summing up, the second generation of telemedicine has made great strides in terms of technology, geography, and interest when compared to the first generation. There seems little doubt that the interest and the advancing technology have assured its future in some form or another. However, with an informed public policy and private action, we have the opportunity to derive more benefits, assure a more prudent investment, and improve health and well-being of people everywhere.

One of the unique and significant attributes of telemedicine technology is its integrative capacity for establishing networks and building partnerships. More benefits and more dividends can be achieved: (1) by establishing integrative telemedicine systems that incorporate all diagnostic and clinical services within health care institutions; (2) by encouraging states, provinces, and countries to develop comprehensive and ubiquitous networks within their boundaries; and, (3) by sharing health care resources among the countries of the world.

To think of telemedicine only in terms of serving remote or otherwise medically disenfranchised populations may be shortsighted, counterproductive, and basically incorrect. To do so has the potential to not only relegate telemedicine to a second tier or level of medical care, but it would also ignore its capabilities for greater system integration and coordination and more efficient production of health for all.

HEALTH AND HEALTH CARE CONTEXT

It is important to place the promise, goals, challenges, and progress of telemedicine within the context proposed health objectives for local, national, and international communities. Telemedicine has been proposed as a modality for delivering health when provider and client, or provider and provider, cannot meet face-to-face because of geography, convenience, or practicality. Hence, the appropriate starting point for understanding the role of telemedicine in health care is to describe the broader context of health care systems and their objectives.

Consistent with the mission of the World Health Organization (WHO), the World Health Assembly has repeatedly addressed global strategies for optimizing health conditions worldwide. For example, in 1977 at Alma Ata, the Assembly developed a consensual proclamation on global health, which was endosed by 192 member countries. It affirmed that the major social goal of governments and the World Health Organization should be attainment of a particular "level of health" by all people of the world by the year 2000. The intended level of health would permit each person to lead a socially and economically productive life. The definition of health implied by this statement was much more realistic than that adopted in the 1948 WHO Constitution as "A state of complete physical, social and mental well-being, and not merely the absence of disease or infirmity." Still, the lofty goal of achieving even this modest level of health among people of the world by 2000 was not practicable.

In 1981, the Assembly adopted a more reasonable and concrete plan under the title, "Global Strategy for Health for All by the Year 2000." In this new strategy, "health for all" did

not imply an end to disease and disability nor that doctors and nurses would care for all citizens in all countries. Rather, the statement focused on equity of access to essential health care services as a desideratum in national health policy. The underlying premise and promise of "health for all" was that available health resources should be equitably distributed and that no one would be denied access to essential health care. In 1994, the Assembly again focused on the issue of equity of access to health services. Indeed, equity of access to health services emerged as the dominant ethical concern of WHO member states and administrators.

The importance of access derives from the uneven distribution of need for health care in every society and in every community. Typically, those in greatest need tend to have the least resources. At the international level, this problem is further aggravated by the persistent disparities between nations in terms of economic, geographic, cultural, and technical capabilities; uneven distribution of resources in relation to need; poor management: and, inefficient use of existing resources.

Echoing similar concerns for the U.S. population, the Office of Disease Prevention and Health Promotion of the U.S. Department of Health and Human Services published *Healthy People 2010*,[1] in November 2000. This publication builds on and expands similar initiatives of the previous two decades.[e] *Healthy People 2000*[2] presented a set of health objectives and targets to be achieved throughout the nation over the first decade of the new century.[e] The national health objectives were established through a "broad consultative process, built on the best scientific knowledge and designed to measure programs over time" (see *www.health.gov/healthypeople*). The detailed objectives can be essentially grouped into two sets:

- Those aimed at increasing quality and years of healthy life for individuals of all ages, and
- Those aimed at eliminating health disparities among different segments of the population.[f]

To achieve these general goals, the report lists 28 action areas, each containing concise goal statements and specific objectives. These areas range from "Access to Quality Health Services" (including preventive care, primary care, emergency services, long-term care and rehabilitative services), through "Mental Health and Mental Disorders" (including mental health status improvement, treatment expansion, and state activities) to "Vision and Hearing."

For two decades, various editions of *Healthy People* have served as strategic planning tools for the federal and state governments as well as other private and public partners. The single overarching purpose is to promote health, prevent disease, and provide care for the sick and disabled as well as to ameliorate pain and suffering and to provide palliative care for the dying. Such a health care system necessarily includes the entire range of health-related activities aimed at these objectives.

It is important to recognize, however, that health systems are unique to each society and culture—even within countries. In each instance, the system reflects: (1) a combination of cultural values and practices, (2) the extent to which science and technology are incorporated into the practice of medicine, (3) the level of health sophistication, (4) relative affluence, and (5) each society's investment in health and health care. Indeed, the health system of each country or region is the unique blend of public and private, organized and unorganized, and formal and informal services directed toward the production of health.

THE ROLE OF TELEMEDICINE

Telemedicine has developed concurrently with, but until the last decade, largely separate from the development of global, national, state,

[e]Preceded by Healthy People, 1979, Surgeon General's Report; Promoting Health/Preventing Disease: objectives for the Nation (1980); The 1990 Health Objectives for the Nation: A Midcourse Review. Health of the Nation: Highlights of the Healthy People 2000 Goals—1995 Report to Congress.

[f]*Healthy People 2000* included a third objective, namely, "Achieve Access to Preventive Health Services for All." Prevention and Health Promotion, April 1999.

and local health objectives such as those described above. Nevertheless, the impetus for telemedicine development correlates with issues and obstacles facing health objectives in the larger context, namely inequity of access, uneven quality and cost inflation on the one hand, and increased use and continuing development of information technology, miniaturization, and telemetry, on the other hand.

It is not surprising that today we are witnessing the confluence of telemedicine and the many functions of health care systems. The range of specific functions that telemedicine or interactive health communication (IHC) can provide, as identified by Eng and Gustafson,[3] includes the following:

- Information transfer—on demand provision of individualized health information.
- Informed decision making—to facilitate health decision making process of individuals or to facilitate communications between health care providers and individuals.
- Health behaviors—to promote adoption of and maintenance of positive health behaviors by individuals and communities.
- Peer information and emotional support—through providing wellness information and explaining associated benefits and costs.
- Self-help and self-care—to help users manage health problems without direct intervention from a health care professional or to supplement existing health services by facilitating remote health monitoring and information.
- Demand for health services—to enhance the use of effective health care services and reduce the use of unnecessary services.

Therefore, in the context of regional, national, and international health goals, telemedicine can play a critical role in achieving both short- and long-term objectives. The trend to contain and reduce health care costs will be supported by systems that promote self-help, manage demand for care, and replace or supplement face-to-face interactions with electronically mediated ones. In geographically and functionally fragmented health care systems, telemedicine can help integrate care delivery by enhancing provider communication and centralizing information sources. As health care systems continue with attempts to contain costs, some components of care delivery may be reassigned from relatively expensive professionals, such as physicians, to less costly providers, such as nurses and other health professionals. In addition, information technology will let more patients receive care in their local health care facilities rather than in most costly and often distant medical centers, while geographically remote specialists supervise care in local facilities electronically.

At another level, with improvements in the technical capacity of health departments, information technology, and interactive health communication can become a central strategy for community health education, community outreach services, and social marketing for positive health behaviors.

CONCLUSION

This discussion has focused on the development of telemedicine vis-à-vis global, national, regional, and local goals for improving the "health for all." In this context, telemedicine can facilitate and enhance the progress toward these goals by improving access to health services and health-related information, improving the quality of health care, and containing the rising costs of health care. It can also contribute to increased awareness of health problems, preventive health behaviors, public and community health education, and improved self-care.

Central to telemedicine's potential for contributing to current and future efforts to achieve many of the health objectives discussed above, however, is its performance in the clinical setting. Clinical telemedicine applications can be found in practically all clinical specialties and subspecialties. Regardless of specialty, telemedicine, advanced telemetry, and telecommunications technology have the potential to reconfigure the medical care landscape, making high-quality specialty care accessible regardless of provider and patient location. Telemedicine can, thus, succeed in electronically redistributing and providing a more equitable distribution system of clinical services

than is possible with the conventional modality of medical care delivery. Telecommunications and information technology can also reduce the risk of clinical "error" by providing improved, expanded, and readily accessible patient information. Finally, telemedicine can give remote providers access to the lastest medical information in the literature or consultative sources.

Thus, as a new modality of medical care and health care delivery, telemedicine is optimally situated to make major contributions to the universal health care goals and objectives. As such, it represents an efficient instrumentality for achieving health care goals nationally and internationally. And yet, after more than a decade of active research and development activity in telemedicine, we have not yet adequately summarized, critiqued, and presented in a systematic and cogent fashion what has been learned from research, development and evaluation. Once again, the purpose of this symposium (and this report) is to consolidate the knowledge gained to date; to frame the issues to be addressed and the methodologies to be used; and to chart the future direction for policy development, both nationally and internationally. It is only upon this firm foundation that telemedicine can fulfill its considerable promise efficiently and effectively.

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