Telemedicine: An Inquiry in the Economic and Social Dynamics of Communications Technologies in the Medical Field

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ABSTRACT

The health care industry in the United States has been experiencing substantial and ever increasing cost pressures. At the same time, many forces are revolutionizing the way health care is financed and delivered. Telemedicine, in this respect, offers significant potential for addressing some of the challenges faced by the health care industry. However, despite the fact that Telemedicine technology has existed since the 1920s, the use of Telemedicine has not been widespread. The use of the diffusion of innovation theory as an organizing framework, coupled with results of a survey of telemedicine professionals at the Global Telemedicine 2000 Conference in Chicago in 1996, identifies telemedicine’s potential as well as the barriers that are impeding its wide-spread application. In general, Telemedicine’s ability to provide greater and more extensive health-care at lower costs is being hampered by social constraints in society, including i) low compatibility with existing medical practices; ii), complexity of telemedicine equipment and interfaces; iii) absence of reimbursement by third party agencies; and incompatibility of state laws regarding Telemedicine and licensure issues.

A case study of the USC-ABC Telemedicine project further to elucidates how attention to some of these factors can promote the success of any Telemedicine project. Two key lessons in this case are (i) The importance of the efforts and vision of a single individual and (ii) need for suppliers to be acquainted with the needs and demands of Telemedicine users.

In many test-bed projects, Telemedicine has proven to be a reliable approach to some of the problems in the health care industry and shows promise for achieving greater medical coverage for the American population. However, a more extensive use of Telemedicine would only attain if five conditions prevail, namely; i) a change in medical culture and attitude; ii) changes in model of health care delivery as the current methods of funding requirements from state and federal sources restrict commercial opportunities for equipment leasing and data storage; iii) cooperation and coordination between corporations, government bodies and health care providers; iv) definitive analyses of the costs and benefits, both economic and social, of Telemedicine; and v) identification of the commercial and business opportunities that will be generated with the widespread use of Telemedicine.

In the final analysis, the increasing and accelerating costs of health care, coupled with the aging of the U.S. population are factors favoring increased the adoption of Telemedicine. This report identifies some of the barriers that can be addressed by policy-makers, broadband equipment manufacturers and service providers, and key players in the health care industry, to exploit the opportunities presented by these changes.

1. Introduction

Although aggregate and per capita costs of health care in the United States are the highest in the world, many Americans still remain uninsured, under-insured or live in communities that are medically under-served. A recent report from the Health Care Financing Agency (HCFA) estimates that annual health care expenditures exceed $900 billion, which amounts to more than $2 billion dollars a day or the equivalent of almost 15% of the Gross Domestic Product (Clyburn, 1996). In sharp contrast, it is estimated that some 15% to 25% of Americans live in counties that are defined as medically under-served (Office of Technology Assessment, 1990). Equally important between 1980 and 1989, the costs of medical services increased by 99%, or at twice the rate of inflation during the same period (National Telecommunications and Information Administration, 1991). Furthermore, in 1994, the 4.8% increase in medical costs still represented more than twice the overall rate of inflation of 2.3% and exceeded the increase in workers’ earnings of 2.5% (Swartz, 1994).

In this regard, Telemedicine, generally defined as “the use of telecommunication and computer technologies with medical expertise to facilitate health care delivery” (Kim, Cabral & Kim, 1995), has significant potential for developing into an integral component of the global health care system. Through remote sensing, collaborative patient care and access to electronic libraries and medical databases (Lindberg, 1994), Telemedicine can engender better and more extensive access to health care, lower medical costs, reduce the isolation of medical care professionals and increase medical productivity.
Although Telemedicine has existed since the 1920s \(^1\) (Williams and Moore, 1995), it thus far, has been used only sparingly for real-world patient-physician consultations. A study conducted by Abt Associates found that, even when a broad definition was used, only 18% of all rural hospitals in the US were using Telemedicine. Furthermore, there has been a very limited number of clinical studies documenting Telemedicine’s efficacy as a primary diagnostic and treatment tool (Perednia and Allen, 1995). Rigorous technology assessments that could form the basis for a coherent guide to the cost effective use of integrated systems are also lacking.

Although telemedicine offers significant advantages, its limited use suggests a lack of compatibility with existing experiences and values. The use of the Diffusion of Innovation Theory, as an organizing framework, helps elucidate the benefits that Telemedicine offers to potential adopters and identifies the barriers to the increased and widespread use of Telemedicine.

**Telemedicine under the Diffusion of Innovations Framework**

Some innovations such as pocket calculators or camcorders diffuse from first introduction to widespread use, or critical mass, within a few years. Others, like Telemedicine, require a longer time. Several models can be used to explain the differences in the rate of adoption. Generally, these models dichotomize members of the social system into early adopters and late adopters.

Late adopters either observe and imitate early adopters, or they communicate with them and are persuaded or induced to adopt these services, products or technologies, and critical mass is eventually achieved. One such model for these processes, the “diffusion of innovation theory,” (Rogers, 1995) suggests five characteristics which can be used to describe innovations and analyzes how individuals’ perceptions of these characteristics affect the adoption rate. These are summarized below:

<table>
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<tr>
<th>Relative Advantage</th>
<th>Definition</th>
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<td><strong>Relative Advantage</strong></td>
<td>the social and economic advantages that can be derived from adopting the new product</td>
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<td><strong>Reduction of Uncertainty</strong></td>
<td>compatibility: the degree to which an innovation is perceived as consistent with existing values and past experiences of the adopter; complexity: the extent to which the innovation is perceived as difficult to understand and use; trialability: the degree to which the innovation can experimented with on a limited basis; observability: the degree to which the results of an innovation are visible to others</td>
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<tr>
<td><strong>Social System</strong></td>
<td>nature of the social system, which is the set of interrelated units engaged in joint problem solving, its structure (formal and informal) and its norms</td>
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<td><strong>Type of Innovation-Decision</strong></td>
<td>Optional-based or authority/consensus-based decision making</td>
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<td><strong>Communication Channels</strong></td>
<td>extent of change agents’ promotion efforts where change agents are opinion leaders who could influence other members of the social system to adopt (or conversely not adopt) an innovation</td>
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Using this framework helps elucidate the significant advantages that Telemedicine appears to offer to the potential adopters, as well as delineates the barriers to the increased and widespread use of Telemedicine, particularly its limited compatibility with previous experiences and values.

**Relative Advantage**

**Economic Advantages:**

Although there have been no definitive cost-benefit analyses to determine the economic viability of Telemedicine projects, several studies have demonstrated the cost saving potential of Telemedicine. For example, a study prepared by the Arthur D. Little consulting company estimated the benefits at $36 billion annually (Moore, 1995). These savings could be generated from: (i) reduced costs for serving patients, through savings in time and travel for doctors and patients, fewer unnecessary referrals, and the replacement of doctors with less medically trained personnel supported by Telemedicine (Moore, 1995); ii) cost savings from the provision of better health care, generating cost reductions from early diagnosis and treatment. The cost saving benefits of Telemedicine have been substantiated in several studies, including following:

- Georgia’s test of 30 patients who were first seen in person and then over video showed no differences in diagnosis. About 81% of the patients seen were retained and treated locally, thus representing increased revenues to the local providers, increased revenue to the consultant and decreased costs to the patient.

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\(^1\) A form of telemedicine was used in the 1920s, when radio was used to link public health physicians standing at watch at shore stations in order to assist ships at sea that had medical emergencies. In the late 1950s, attention was drawn to closed circuit \([television] \) systems using microwaves (Kim, Cabral, Parsons et alii, 1995), and in the 1970s satellites were used in large demonstration projects linking Alaskan and Canadian villages under the auspices of the NASA.
• Texas Tech MEDNET demonstrated savings of $1000 per patient when the patient was locally treated.
• Texas Telemedicine demonstrated a break-even analysis in 2.7 years after lower costs for local treatment, travel time for physicians and patients, and opportunity costs were considered.
• Telemedicine Canada (Toronto) and Memorial University in Newfoundland have demonstrated full cost recovery for educational efforts. The case of Texas Tech MEDNET, which demonstrated savings of $1000 per patient when the patient was locally treated (Williams and Moore).

Currently, however, for many medical practitioners, the cost-reducing effects of Telemedicine are negligible or even non-existent. Cost savings in travel time tend to be only important for medical practitioners in rural and under populated areas. Also, the patient’s costs of travel are borne by the patients and no cost savings accrue to the doctors. In fact, Telemedicine may even have a negative economic impact for some doctors by disrupting referral patterns and eliminating some sources of income (Abt and Associates).

Social Advantages:
Telemedicine has the potential of reducing of the isolation of medical professionals and offers some social advantages in the form of new, and potentially more satisfactory, interaction among people in the medical field. CTM’s survey of the participants of Global Telemedicine 2000 conference in June 1996² substantiates some of the economic and social advantages that Telemedicine affords. For example, as shown in Figure 1, over 75% of participants who have had 20 telemedicine consultations or more a month have observed enhanced quality of medical decisions through collaboration, provision of health care to previously underserved or unserved areas, access to specialty care and increased speed of diagnosis and treatment to some or to a great extent. However, it is equally important to note that only about 20% of respondents had observed Telemedicine leading to a reduction in costs in providing services. This may reflect the high overhead costs currently related with Telemedicine projects, ranging anywhere from $50,000 to $100,000 to equip a typical interactive video site (Perednia and Allen, 1995). This represents a significant barrier to Telemedicine.

² It should be noted that CTM’s survey of participants at the Global Telemedicine Conference was not a random sample but a survey of 100 specialized medical professionals who were already using telemedicine or were in the process of establishing telemedicine projects.
Reduction of Uncertainty

Telemedicine also requires sophisticated hardware and high bandwidth\(^3\) as most Telemedicine applications need to be real-time, and “the more challenging and difficult the remote consultation and diagnosis, the higher bandwidth and processing power the clinical application will require” (Kim et. al., 1995). In sum, the technologies supporting Telemedicine are complex and, in a sense, disparate as they need to support videoconferencing, data transfer and database systems. In practice, these separate components must perform as an integrated unit to the user, hence accentuating the importance of user interfaces and information exchange standards. In general, however, Telemedicine can be characterized as involving a high degree of uncertainty.

![FIGURE 1](image)

**Percentage of Respondents with 20 Telemedicine Consultations or More per Month Who Have Observed the Following Benefits to Some or Great Extent**

**Compatibility:**

Although medicine is an information-intensive professions (Lindberg, 1994) and “every medical encounter is also an information transaction” (Burgener and Kienz), the compatibility of Telemedicine with current practices and values is low, since there is a long tradition of personal contact between doctor and patient. For example, in 1990, an AMA survey showed that 85% of those surveyed were “very satisfied” with their last visit to a doctor and 90% were “pleased” with the way they had been treated (Wasley, 1992). This lack of a tradition of instrument-mediated contact between patient and doctor is a major obstacle and the replacement of human, personal contact (high touch) by

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\(^3\) It should be noted that Telemedicine applications can be implemented over the Plain Old Telephone System, like the six projects “emphasizing telephone-related technologies: phone, fax, slow scan video, audio graphics” reviewed by Witherspon et al. (93).
machine intervention (high-tech) might require a change in the present culture of medicine. Although compatibility is higher in certain medical specializations, where the contact between the MD and the patient is mediated by equipment, like Radiology, early experiments with Telemedicine in these areas failed for technical reasons. Also, numerous Telemedicine applications require large bandwidth. The quality of a video image depends on bandwidth, so for Telemedicine to become widely used, high-bandwidth must be available.

**Complexity**

The absence of a technological tradition regarding information technology in medicine negatively affects the perception of Telemedicine’s complexity. Some Telemedicine projects have cumbersome user interfaces and require extensive technical knowledge. Studies have shown that user friendliness of equipment is crucial for the success of Telemedicine (Mary Moore, 1995). This sentiment is further reflected in CTM’s survey, as shown in Figure 3, where 93% of participants with 20 Telemedicine consultations or more a month found the use of videoconferencing equipment related to Telemedicine to be very easy or easy to use. Not surprisingly, some 67% of participants found radiology and electrocardiogram equipment very easy or easy to use since such equipment have had the longest use in Telemedicine. In marked contrast, however, even among frequent users of Telemedicine, only 53% percent of participants found imaging retrieval systems very easy or easy to use, while thirty-three percent found these systems to be very difficult or somewhat difficult to use. Similarly, some 40% of participants found integrating patient records very difficult or somewhat difficult to use and only 30% found these systems to be very easy or easy to use, reflecting, in part, the incompatibility of the systems.

Furthermore, the lack of standards in Telemedicine hardware, software and networks limits not only modular upgrading of the technological base, but also increases the cost of improvements. For example, although the DICOM standard was adopted in 1985 as the common format for digital medical imaging systems and several different vendors claim that their equipment conforms to that standard, many practitioners of telemedicine assert that images are not transparently interchangeable between vendors (Frederick George III, MD, 1996). CTM’s survey substantiated the importance of common standards, training of physicians in the use of Telemedicine, user friendliness of equipment and image quality. As shown in Figure 3, over 80% of participants with 20 or more Telemedicine consultations per month rated the implementation of standards and specifications for procedures, equipment, personnel, licensing and quality control as important or very important factors in Telemedicine.

**FIGURE 2**

*Complexity of Use of Telemedicine Equipment*

![Complexity of Use of Telemedicine Equipment](image)

4 Personal interview with Dr Frederick George, III in April 1996 at USC Health Sciences Campus.
**Trialability**

The ability to experiment with telemedicine services on a limited basis before adoption is low, since there is a requirement for specialized equipment and infrastructure. In Telemedicine, particularly, the absence of technical standards and “off-the-shelf” solutions makes trialability even more limited.

**Observability**

One of the greatest barriers to the increased use of Telemedicine, currently, is the lack of observability of its benefits, since the benefits are usually limited to the participants of the network with a small spillover effect. CTM’s survey found that only 26% of participants within a major city and only 7% of those in a rural county or small town observed or experienced Telemedicine leading to a some or great reduction in the costs of providing services. Similarly, only 27% of participants within a major city and only 13% of participants from rural counties or small towns have observed Telemedicine avoiding duplications of services, technologies and specialization. Furthermore, only 47% of participants from rural counties or small towns have observed Telemedicine providing health care to previously underserved or unserved areas as compared to 61% for participants within a major city.

Overall, as illustrated in Figure 4, CTM’s survey found that Telemedicine affords two major advantages for rural communities or small towns; namely allowing access to specialty care and providing continuous and flexible access to information by health care providers: some 53% of participants in rural counties or small towns have observed Telemedicine providing continuous and flexible access to information by health care providers as compared to 37% of participants within a major city.

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**FIGURE 3**

Percentage of Respondents Rating the Following Factors as Important (4) or Very Important (5) in the Use of Telemedicine Nationally

- User friendliness of equipment
- Quality of image
- Appropriate software
- Reduction of telecommunications tariff
- Universally accepted system of reimbursement
- Confidentially and security of patient records
- Greater compatibility of state laws governing telemedicine
- Training of physicians in the use of telemedicine
- State and federal funding
- Implementation of standards and specification for

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*Note: The figure shows the percentage of respondents rating each factor as important or very important.*
FIGURE 4
Percentage of Respondents within Each of the Following Settings Experiencing or Observing the Benefits of Telemedicine to Some or Great Extent

- reduces costs of providing services
- avoids duplication of technologies and specialization technologies and specialization services
- provides continuity of care patient records and
- reduces sense of isolation for health care professional
- continuous and flexible access to information by health care providers
- improves patient involvement
- increases quality of teaching and education medical
- enhances quality of decisions collaboration patient between physician, consultant and patient medical
- provides health care to underserved or unserved areas previously
- allows access to specialty care
- increases speed of diagnosis and treatment

Legend:
- Rural
- Near Small City
- Suburban
- City
Social System

Although, the social system surrounding the adoption of Telemedicine is very structured and complex, the lack of a clear position on Telemedicine, in general, by the American Medical Association and most medical colleges and medical schools, save the American College of Radiology, presents another impediment. This lack of clear positioning and ambivalence has contributed, in part, to four major social impediments to the increased use of Telemedicine.

In the first instance, the cost of implementing a telemedicine infrastructure is a large impediment to widespread use of the technology. CTM’s survey results confirm this. Currently, a large majority of Telemedicine initiatives are sponsored by organizations where reimbursement is not crucial, like research centers, the Armed Forces or State-owned hospitals, since these are frequently financed by demonstration grants. Only an extremely small number of for-profit medical centers are involved in Telemedicine and many of these, like the Mayo Clinic, are employing closed Telemedicine systems (Tangalos, 1994). Furthermore, medical organizations are reluctant to purchase equipment because of the risk that it will be quickly outdated.

New legislation shows promise in overcoming the payment issue of telemedicine. In California, for example, legislation prohibits state payers from making face-to-face contact between physician and patient a condition of payment. On the federal level, President Clinton has signed a bill that requires reimbursement for telemedicine in rural areas. Payment still does not include reimbursement for telephone line charges or facility fees. However, this is a positive step forward that could pave the way for expanded reimbursement for telemedicine services. Until now, Medicare routinely paid only for radiologists to read images via store-and-forward telemedicine.

Secondly, under the present individual state licensure system the potential of Telemedicine is limited to the somewhat arbitrary borders of a state, thus limiting geographic reach. A new system, enabling physicians to take full advantage of communication networks, should be implemented in order to unleash the potential of Telemedicine.

Thirdly, “there is significant uncertainty regarding whether malpractice insurance policies cover services provided by Telemedicine” (Western Governor’s Association, 1995). The legal problems associated with Telemedicine malpractice liability are especially intricate when services crosses state borders. Liability is a significant problem for doctors as shown in a survey by the Washingtonian magazine which concluded that seventy-eight percent of physicians are engaged in practicing “defensive medicine” with the result that malpractice liability premiums increased at an average annual rate of some twenty-two percent during the 1980s (Wasley, 92).

Finally, like other communications technologies, there is a concern regarding the security of personal medical information stored in Telemedicine systems. Sanders (94) notes the possible use of encrypting algorithms and legal precedent (yet to be defined) determining “reasonable and customary” efforts in protecting individual’s information. The importance of these issues is substantiated in CTM’s survey, where, as shown in Figure 5 over 70% of the respondents with 20 telemedicine consultations or more a month viewed the lack of a universal system of reimbursement as a serious or very serious barrier to the increased use of Telemedicine. In addition, over 50% of the respondents viewed the lack of standards and the incompatibility of state laws as serious or very serious barriers.

Type of Innovation-Decision

The decision of implementing most current Telemedicine projects seems to be authority based, where users (especially doctors) are not participant decision-makers. Most projects are initiated by policy-makers, like State Public Health officers and Armed Forces leaders. In the future, one can expect a move to a consensual decision-making process for adoption. Several case studies of Telemedicine projects have shown that the success of many of these projects can be attributed to the organizational culture, commitment of management to adopt Telemedicine and the administrative efficiency of the organizations (Moore, 1993).

6 Under the Budget Reconciliation Act of 1997, Medicare will pay for teleconsultations involving a beneficiary residing in a county in a rural area designated as a “health professional shortage area.” About 3.3 million Medicare beneficiaries live in the affected rural areas. Estimates from the Congressional Budget Office show that reimbursement will cost $200 million during the first five years, offset by savings of about $50 million.
7 recommending possibly redundant or unnecessary procedures only to reduce the risk of malpractice suits
FIGURE 5
Percentage of Respondents with 20 Telemedicine Consultations or More
A Month Who Rate the Following as Very Serious (5) or Serious Barriers (4) to the Increased Use of Telemedicine

Communication Channels

The interpersonal communication among physician and health care administrators is a primary source of communication regarding Telemedicine decisions. Other sources include vendors of equipment and services, the professional journals and the media. Interviews with telemedicine directors have found that those leading such projects tended to be charismatic entrepreneurs, articulate, enthusiastic, energetic, self-sacrificing, obsessed with their users, impatient for change and true believers in their cause. Furthermore, physicians who were most likely to use telemedicine were described as being:

“inquisitive, confident enough to ask questions and not be intimidated by specialists, and humble enough to believe that they did not know all the answers. They demonstrated qualities of lifelong learning, often used many sources for information, were often outgoing, preferring personal contact for consultants, and were ...often information influentials who conducted telemedicine consultations and often went on to educate other local colleagues about the outcomes of the consultations. Those consulting specialists who provided telecommunication services were characterized as being opinion leaders in their fields, experienced, providing a high standard of care, being flexible and adaptable and as being altruistic” (Williams and Moore, 1995).

A communication barrier for Telemedicine is a consequence of a much higher number of adopters in small rural hospitals. Doctors and administrators from these places are not especially well positioned to serve as a reference group for most of medical professionals and institutions.

Diffusion of Telemedicine and the USC-ABC Telemedicine Consortium

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8 Pacific Bell, for example, sponsors the Telemedicine project at the University of Southern California.
The Advanced Biotechnical Consortium (ABC) at the University of Southern California (USC) consists of industry, academics, the medical community and federal laboratories. The objective of the consortium is to develop telemicine applications using high-performance computing and communications technologies. It was formed in 1993 at USC and includes over 30 major California hospitals and rural medical facilities. With a few minor exceptions, the equipment for the project has been donated or loaned.

This pilot program was funded partly by a grant from CalREN (California Research and Education Network) which is a foundation established in 1994 by Pacific Bell to encourage the development of high-bandwidth applications. The USC project is the largest CalREN program with a $11/2 million dollar loan. ABC’s goal of creating a three-dimensional image from a two-dimensional image in a few seconds, compared to the usual 24 hour time lag, was the innovation that convinced CalREN to fund the project.

The vision for the consortium was conceived by Dr. Frederick W. George III, Professor Emeritus of Radiology and Radiation Oncology who decided that the complex political, legal and technical issues surrounding Telemicine could best be dealt with by incorporating the support of a variety of organizations within and outside the University. The consortium began in and was endorsed by USC’s Radiology department and almost immediately, joint projects between private industry and the university were instituted. For example, the Jet Propulsion Laboratory provides access to its supercomputer, with physicians’ workstations provided by Sun Microsystems and Hewlett-Packard. Imaging equipment comes from Picker International. The foundations of the ABC project is the USC Helpnet Project, whose original primary objective was to improve billing procedures and thus generate additional revenue for the School of Medicine. The project later adopted a secondary goal of providing a higher level of service to the patient base through better access to patient records, and faster and better access to data.

Helpnet is a highly advanced integrated electronic patient medical record system. It provides a complete consolidated clinical/patient record system for all the USC hospitals and community practitioners affiliated with the USC School of Medicine. A patient’s entire medical record will be able to be accessed on-line (security measures exist to prevent unauthorized access). The record can include video images, full-motion clips, 3-dimensional volumetric images from PET, CT, MRI, or digital X-ray scans. In addition, whiteboard image viewing and videoconference tools are provided so physicians can make notations at the same time they are viewing the images. These notations can be shared with other physicians or legal and social services personnel who can view the data simultaneously. Helpnet will provide billing services, hospital and practice management, order/entry, managed care services, image indexing and retrieval, electronic medical records, and patient demographics. It is a repository and is designed as an open system.

The USC consortium has attracted interest due to its ambition, and the success it has achieved in its early stages. The USC project goes beyond many of the current telemicine projects now underway in terms of technological advance due to the implementation of ATM technology. USC hospitals make up the world’s largest research university medical complex, so applications have extremely high requirements for data volume, storage requirements, and distance since some of the hospitals are 20 miles apart. The size of the network and the fact that it will serve a diverse group of patients across a wide area means that the results of this project will have significance in assessment of the prospects for high performance computing and communications in health care. The USC hospitals patient base includes almost one-tenth of the total United States population.

The use of the diffusion of innovation framework has helped identify some of the potential and realized benefits of Telemicine as well as some of the barriers impeding the increased use of Telemicine nationally. An analysis of the formation of the USC-ABC Telemicine Consortium helps underscore some of the issues in Telemicine and, more importantly, accentuates the significance of the “reduction of uncertainty,” “communication channels” and the “social system” as factors affecting the widespread use of Telemicine. The project’s collaboration with suppliers in the development of the VOXAR and VOXnet systems, demonstrates attempts at “reduction of uncertainty.” In particular, USC’s Telemicine project underscores the fact that the success of Telemicine resides in the efforts and vision of respected and accomplished individuals who are central in securing cooperation from corporations, government bodies and health-care providers.

Formation of USC-ABC

The consortium began in and was endorsed by USC’s Radiology department and almost immediately, joint projects between private industry and the university were instituted. For example, the Jet Propulsion Laboratory provides access to its supercomputer, with physicians’ workstations provided by Sun Microsystems and Hewlett-Packard. Imaging equipment comes from Picker International. The foundations of the ABC project is the USC Helpnet Project, whose original primary objective was to improve billing procedures and thus generate additional revenue for the School of Medicine. The project later adopted a secondary goal of providing a higher level of service to the patient base through better access to patient records, and faster and better access to data.

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All of USC’s major hospitals along with the 30 affiliated community hospitals and clinics in Southern California are now, or will soon will be, linked by a fiber optic network, which eventually can be extended to telemedicine networks abroad. In addition, there are plans to tie in to hospitals with telemedicine programs which are outside the USC system.

USC-ABC has implemented a full feature high-speed test bed medical network which comprises an ATM backbone with multiple data links/bridges to the community. The links are phone lines, ISDN data links (primary and basic rate), and frame relay (ethernet bridging). Access is campus wide through ethernet and worldwide access is over the Internet. Eventually, physicians will be able to teleconsult from any on-line facility including their residence.

**USC ABC Project and Relative Advantage**

The goals of the ABC initiatives are to improve patient treatment, to reduce the time and testing required for diagnostics, and to reduce health care costs. One of the ultimate goals is to provide distance-education, once connectivity is extended to teaching locations.

The ABC project has important applications for opthalmology. Using store-and-forward techniques, retinal images can be transferred making diagnosis faster, resulting in a second opinion being rendered in a couple of seconds. As a result, referral costs and hospitalizations, which represent large expense, should decrease. Also, the quality of eye care can be enhanced since electronic enhancement of eye images is often better than direct eye examination.

Another application beyond the needs of healthcare providers is the USC system’s support for the SCAN (Suspected Child Abuse and Neglect) Center’s efforts. The procedures for documenting child abuse cases can be sped up substantially. A physician at the county hospital can guide an examination from a distance, utilize freeze frame capabilities, and make records. The child’s medical records can be accessed by the physician who can make medical decisions quickly, and images can then be transferred to law enforcement officials.

In the future, the ABC project plans to form networks of linked hospitals, medical schools, clinics, and doctor’s offices to facilitate collaboration and the sharing of information across time and space, thus leading to higher quality healthcare.

**USC-ABC Project and Reduction of Uncertainty**

The switch used in the consortium’s ATM network was developed by Whitaker for Pacific Bell to be used in their provision of video-on-demand (VOD) services. After PacBell completed its business model, however, it was determined that there was not a market for VOD services. Meanwhile, Whitaker had invested substantially in the development of this high-speed data manager, and now needed to find a market. USC stepped in, and worked with Whitaker to develop a high-speed image server for their network. Although substantially scaled down from the original box, it will have capabilities for various types of data including computer, static images, and video data. A physician will be able to call up teaching tapes, conferences, and grand rounds from library archives.

**VOXAR**

The Voxar imaging software is a defense conversion project and the first major ABC project which permits the reformatting and merging of radiological images to create 3-D images from a 2-D images in seconds. In addition, imaging archiving projects include the development of real-time image depositories and linking stored digital images with patients’ electronic charts. The ability to store CTs, MRIs, PETs, and computerized X-rays allows them to be quickly retrieved and sent to various facilities simultaneously. Three-dimensional images are valuable because they provide highly accurate information about the location, size, and composition of anatomical structures, disease processes, and tissues.

In 1994, USC-ABC, in conjunction with JPL and Northrop Grumman, successful simulated for the NTIA (National Telecommunications and Information Administration), an emergency frequently faced by rural hospitals: a critically ill patient arrives at the hospital with records incomplete and scattered among several facilities and requiring immediate transfer. In the demonstration, the patient’s

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15 Description of the USC-ABC network is based on Edward Chow, and Rob R. Zalunardo, “The Virtual Academic Medical Center: A Concept Paper,” (October 1994), USC-ABC.
16 Three-dimensional images can be rotated, magnified, and manipulated in a way that would otherwise be impossible. These representations allow for quicker and more accurate diagnosis, in particular for diseases of the brain.
17 Pacific Bell, CalREN info
18 The NIIT is an industry-led information infrastructure technology group. In September of 1994 the NIIT and ABC demonstrated a transcontinental advanced biomedical data exchange to Congress. An ATM (Asynchronous Transfer Mode network) was set up between major US cities representing the first national ATM network for medical applications.
medical ID card is swiped through a computer which brings up all the patient’s medical records across the country. The patient’s MRI and CT scans are sent to the Cray computer at JPL and are converted into rotating 3D images. By the time the patient arrives at USC, physicians have already located an unnoticed abnormality in his abdomen, and operate immediately, which saves his life.\textsuperscript{19} Trans-Atlantic telemedicine was demonstrated by the ABC project from Paris at the American Radium Society’s annual meeting in 1995, as doctors in Los Angeles communicated in real-time with doctors in Paris while viewing three-dimensional volumetric images which were rotated, highlighted, and marked with notations. This demonstration showed that it was technically possible to have transoceanic links for telemedicine.

**VOXnet**

VOXnet is a multimedia patient database which can be accessed with an HTML interface. In addition to traditional text based information about a patient, such as name, address, etc, visual information is also available. The World Wide Web (WWW) provides access to VOXnet. The graphics tool kit allows a series of CT scans to be viewed in a manner customized to the user. The user can page through the scans in an easier manner than the traditional means of sorting through a large pieces of film. In addition, once the patient is scanned at the hospital, the physician can access instantly the data from home.\textsuperscript{20}

**Virtual Academic Medical Center**

The entire range of computer applications to be offered by the ABC consortium is referred to as the Virtual Academic Medical Center (VAMC), a prototype that includes Helpnet, video conferencing, image transfer, distance learning, telemedicine, and data sharing and can be accessed from any location world-wide. This project is being developed to offer doctors high quality training and consultation with academic physicians. The project strives to develop a collaborative framework for physicians to share medical data and images in real-time, and online.\textsuperscript{21} VAMC has been exhibited in several demonstrations around the world including the Department of Commerce, the American Radium Society and the Networld+InterOp conference. Although the WWW is now the user interface to finding resources in the VAMC, it is not sufficient for a number of medical applications. Physicians need to do more than simply view an object. Rather, they need real-time video capabilities from remote sites that have enough definition to support the rendering of medical opinions. In addition, they need the capability to rotate 3-dimensional images and highlight specific areas. The WWW at present does not support these capabilities. The WWW is still the easiest way to deliver services, since people tend to be familiar with it, so lengthy training is not required for use.

One of the key advantages of the system is that the user only needs to point and click to conduct a videoconference or send and request images.\textsuperscript{22} Efforts have been made to make Helpnet even more user friendly by providing cheat sheets. Data entry personnel have also been employed to further minimize the need for doctors to cope with the technological aspects of the system. Despite these effort, however, the ABC project, like many of the other Telemedicine projects, report a reluctance by some doctors, especially among members of the senior medical staff, to adopt this new approach as it entails a change from traditional practices to more technology-intensive processes.

In contrast to the reluctance of the doctors, patients have been more receptive to the telemedicine applications. ABC consortium members anticipate increased patient satisfaction as a result of cost-savings, reduced waiting time, and shorter hospital stays. Other benefits according to the ABC staff include: fewer lost records and less duplication of tests, and timely availability of data enhancing inter-physician communication.\textsuperscript{23} At present, the ABC project is intended for physicians’ utilization. It is projected that patients will benefit indirectly, however, as hospitals become more efficient through use of advanced communications.

**Conclusion**

At a macro level, the diffusion of Telemedicine is being accelerated by a concern with health care costs and demographic changes. The cost pressures of health care have already forced major changes in the sector structure; the emergence of the Health Maintenance Organizations (HMOs), non-existent in 1970 and now with more than 56 million beneficiaries, probably best exemplifies this. The demographic changes, specifically the aging of the population in the U.S. and most industrialized countries, are generating social pressures in favor of the higher productivity that Telemedicine can bring (Gott ,1995).

The eventual large-scale adoption of Telemedicine could cause radical changes in the structure of power and interests in the medical profession, in particular, and society, in general. These potential outcomes may further act as a barrier against its wide-scale adoption. In the


\textsuperscript{22} The Advanced Biotechnical Consortium of the University of Southern California, “Trans-Pacific Consulting Via Advanced Telemedicine A Concept Paper.”

\textsuperscript{23} NII Awards home page - WWW.
first instance, the massive adoption of Telemedicine would certainly require a very different organizational arrangement, bringing substantial changes in the way medicine is practiced. The full effectiveness of Telemedicine, however, will only be achieved when some medical responsibilities are delegated to physicians’ assistants and nurse practitioners. This could lead to a power transfer to these groups, with considerable modifications in the differential social standing of doctors and other medical personnel.

Secondly, the legal and operating restrictions on the practice of Medicine have protected the medical profession against intense competition and created a near-oligopoly in the health care industry. Telemedicine has the potential of reducing the barriers to competition, giving patients more treatment options and increasing competition among health care providers. Furthermore, Telemedicine will not only enable competition among doctors of different states or even countries, but also between medical doctors and other medical personnel, like nurse practitioners now empowered by Telemedicine to treat cases previously referred to a general practitioner.

In the final analysis, however, the full potential of Telemedicine will only be realized through: i) change in medical culture and attitudes; ii) changes in the model of health care delivery; iii) current methods of funding requirements from state and federal sources restrict commercial opportunities for equipment leasing and data storage iv) cooperation and coordination between corporations, government bodies and health care providers; and v) definite analyses of the costs and benefits, both economic and social, for Telemedicine.

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