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Toy or Useful Technology? The Challenge of Diffusing Telemedicine in Three Boston Hospitals

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EXECUTIVE SUMMARY

In response to increasing competition and cost pressures from managed-care practices, healthcare organizations are turning to information technology (IT) to increase efficiency of their operations and reach out to new patient markets. One promising IT application, telemedicine, enables remote delivery of medical services. Potentially, telemedicine could reduce costs and increase the quality and accessibility of medical services. However, the diffusion of telemedicine has remained low. We present case studies of telemedicine programs at three healthcare institutions in Boston, Massachusetts to better understand why telemedicine has not spread as quickly or as far as one would expect, given its promise. These case studies describe the environmental and organizational context of telemedicine applications, their champions, strategies and learning activities. Since the three cases represent varying levels of diffusion of telemedicine, they enable the reader to understand how and why some institutions, champions and approaches are more successful than others in diffusing a new technology like telemedicine.

BACKGROUND

Boston, Massachusetts is a city that hosts world-renowned medical schools such as Harvard, Boston University, and Tufts and 25 high-tech, specialty-care hospitals. While noted for their world-class medical expertise, Boston hospitals have also been notorious for oversupply of beds, high costs, and high-use rates. In the 1990s, cost pressures on Boston hospitals increased as many health plans instituted more stringent managed-care tactics and the selection of hospitals for patients. The hospitals responded by entering into merger and acquisition agreements to achieve economies of scale and increase their negotiating power (Katz, 1996). These agreements created integrated healthcare networks (IHCN) spanning the continuum of care from primary care practices to community and teaching hospitals. The challenge for IHCNs is to compete on cost and quality of care by consolidating resources and leveraging expertise within their networks.

One promising approach to these challenges is telemedicine. Broadly defined as the use of IT to deliver medical services at a distance (OTA, 1995), telemedicine is proposed as a solution to

Exhibit-1 Financial highlights of the case study sites, September 30, 1997, ($000)

	AlphaCare	BetaCare[1]	GammaCare
Revenues			
Net patient service revenue	$1,662,755	$607,200	$958,002
Research revenue	$364,672	$83,800	$85,020
Other	$181,578	—	$144,893
Total operating revenue	$2,209,005	$691,000	$1,187,915
Total operating expenses	$2,220,711	$705,303	$1,160,037
Net Income (Loss)	$(11,706)	$(14,303)	$27,878
Non operating revenue	$101,694	$42,381	0
Excess of revenue over expenses	$89,988	$28,078	$27,878

[1] Figures are reported for LifeCare, parent company of BetaCare Sources: Annual Reports of AlphaCare, LifeCare, and GammaCare

problems of accessibility, quality, and costs of medical care (Bashshur, Sanders, and Shannon, 1997). Telemedicine can increase access to care by eliminating distance barriers between patients and caregivers. It can improve quality by enabling medical experts to collaborate on complex clinical problems when patients' disorders cannot be diagnosed or treated at referring sites. It can also reduce costs by enabling in-home monitoring of patients and by eliminating the need for on-call expertise, maintenance of expensive facilities, and transportation of physicians to patients or vice-versa.

Telemedicine systems are based on two types of technologies: (1) "Store and forward" telemedicine uses image capture, storage, and transmission technologies to enable asynchronous exchange of images (e.g., for radiology, dermatology, or pathology images); and (2) "real-time" telemedicine uses videoconferencing technologies to enable synchronous interactions between referring physicians, patients, and consulting physicians (e.g., in psychiatric or rare tumor consults).

Although telemedicine applications have proliferated in recent years (Grigsby & Allen, 1997), the volume of actual telemedicine consultations has remained low (Hassol, 1996). One of the challenges is to develop sustainable business models (i.e., finance systems which demonstrate the attainment and maintenance of profitability over time) for telemedicine applications. Capitated and fee-for-service payment systems are the traditional business models in healthcare. In the capitated payment system, physicians and hospitals agree to accept a set advance payment in exchange for providing healthcare services for a group of people, usually for a year. In the fee-for-service model, they receive a fee for each service they provide. Business models for telemedicine must balance the often conflicting demands of numerous stakeholders. Medical institutions, wishing to reach out to new patient markets, can invest in the development and support of telemedicine applications, but they cannot achieve profitability until physicians use them consistently and frequently. Physicians are primarily interested in models that guarantee their reimbursement for telemedicine consultations (Fendrick & Schwartz, 1994). Medical insurers, on the other hand, will only reimburse consultations once cost-effectiveness has been proven. And regulatory agencies will only certify a telemedicine application once it has been proven that it does not degrade the quality of medical diagnoses.

Aligning the incentives for all these stakeholders is a challenge and engenders a number of barriers to the diffusion of telemedicine. The most commonly cited barrier to regular use is restriction on physician reimbursement for telemedicine consultations. However, a nationwide survey of rural hospitals found no association between reimbursement and utilization of telemedicine (Hassol, 1996). Other commonly cited barriers include restriction of medical practice across state lines, risk of medical malpractice, and lack of high-bandwidth telecommunications infrastructure, especially in the rural areas targeted for telemedicine because of the shortages of caregivers (Bashshur, Sanders, and Shannon, 1997).

Some barriers are social and behaviorial. Telemedicine has been found to change some physician behaviors (Anderson, 1997). For example, psychiatrists may have to consult with their

Exhibit-2. Utilization Statistics, 1997

	AlphaCare	BetaCare[1]	GammaCare
Employees	17,469	14,500	13,362
Physicians	1,663	2,152	NAV[2]
Beds	2,574	1,669	1,551
Admissions	95,176	62,258	62,291

[1] Figures are reported for LifeCare, parent company of BetaCare [2] NAV: Not available Sources: Annual Reports of AlphaCare, LifeCare, and GammaCare

patients over a video link rather than face-to-face and cardiologists may have to base their diagnoses on digital rather than video images. Further, traditional practices and workflow may have to change (Anderson, 1997). For example, a physician's time has to be allocated efficiently between on-site patients and remote patients who request consultations via telemedicine. Real-time telemedicine consultations require the coordination of various schedules: those of the patient, the medical staff involved in the consultation, and the video conferencing staff and room. As the volume of telemedicine consultations increases, the coordination of schedules becomes a serious issue. In order to foster regular use, however, hospitals must figure out how to integrate telemedicine procedures within their extant workflows or develop new ones (Cooper & Zmud, 1990).

SETTING THE STAGE

Out of 25 hospitals in Boston, AlphaCare, BetaCare, and GammaCare[2] had the most active telemedicine programs in September 1996 when our study began. These three hospitals are all not-for-profit organizations and key players in the Boston market. Exhibit 1 provides their financial highlights whereas Exhibit 2 summarizes some of their utilization statistics.

AlphaCare was created in 1994 by the merger of Alpha-A and Alpha-B, academic medical centers affiliated with a world-renowned medical school in Boston. Alpha-A and Alpha-B have traditionally been fierce competitors for top accolades in academia and the tertiary care market. U.S. News and World Report consistently ranks them among the country's top ten hospitals. Since the merger, AlphaCare has evolved into an IHCN that includes primary care and specialty physicians, community hospitals, academic medical centers, specialty facilities, and community health centers. AlphaCare has a tradition of excellence in research and training. Its research revenues reached $340 Million in 1996. Its training programs attract top students from around the world.

BetaCare is a world-class academic medical center in Boston. It is home to two full-service hospitals serving adults and children respectively. It is the principal teaching hospital of a world-renowned medical school, and has a tradition of excellence in medical research. BetaCare experienced financial difficulties until early 1997 when it merged with LifeCare, a non-profit regional healthcare system. In addition to financial stability, merger with LifeCare has brought in the strengths of a broad geographic market, a comprehensive and complementary range of services, high quality teaching and medical resources, and strong managed care penetration.

GammaCare was created in 1996 by the merger of Gamma-A, an academic medical center, Gamma-B, a healthcare network including an academic medical canter, a teaching hospital, and three community hospitals, and Gamma-C, a community teaching hospital. GammaCare also includes physician groups and other caregivers. It was created on the belief that community-based hospitals and academic teaching centers can work together to provide high-quality, personalized health and medical services, while also maintaining excellence in medical education and research. GammaCare offers community-based primary care, specialty services, and health services ranging from wellness programs to hospice care.

AlphaCare, BetaCare, and GammaCare have explored the use of telemedicine to integrate their member institutions, to consolidate resources and leverage expertise within their networks, and to sell medical expertise to remote healthcare institutions. Exhibit 3 briefly describes telemedicine applications developed in the three sites.

Exhibit 3. Description of telemedicine applications at the case study sites

Applications	Technology	Description
Fetal Telemedicine	Asynchronous + synchronous	Ultrasound data of pregnant women is digitally captured off of ultrasound machines in private clinics, compressed, and sent to a tertiary care center for opinions.
Home health	Asynchronous	Vital signs (e.g., blood pressure, sugar level, weight, etc.) of chronic patients at home are regularly transmitted to a hospital's database to enable caregivers to monitor patients' health status.
ICU-ICU Consults	Synchronous	X-ray, CT, MRI, etc. data of patients at a community hospital are digitally captured and sent real-time to physicians at an academic medical center for second opinions.
International Telemedicine —AlphaCare	Asynchronous	X-ray, CT, MRI, etc. data of patients in international sites are digitally captured, compressed, and sent to AlphaCare over telephone lines together with patients' medical history files for second opinions.
International Telemedicine —BetaCare	Asynchronous + synchronous	Patients and physicians in international sites are interviewed by BetaCare physicians over videoconferencing links. X-ray, CT, MRI, etc. data can also be exchanged off-line prior to the consult or on-line during the consult.
Nursing home	Synchronous	Patients and nurses at nursing homes are interviewed by physicians at a tertiary care center over videoconferencing links.
Pre-admission Testing	Synchronous	Pre-surgery interviews of surgery patients in the community are conducted by nurses at the pre-admission clinic over the videoconferencing link.
Rare tumor Consults	Synchronous	A surgeon at a tertiary care center views X-rays of rare tumor patients in a community hospital and interviews them over videoconferencing link to render an opinion.
Telecardiology	Asynchronous	Full motion video of cardiac studies in a community hospital are captured, stored, and transmitted to a tertiary care center for second opinions.
Tele-dermatology	Asynchronous	Digital photographs of skin lesions are taken in a primary care setting and sent to dermatologists at a tertiary care center for opinions.
Tele-ophthalmology	Asynchronous + synchronous	Eye images are captured via cameras in a primary care setting, compressed, and sent to ophthalmologists at a tertiary care center for opinions.
Telepathology	Asynchronous	Sections of pathology slides are digitally captured off of a micro scope, compressed, and sent to pathologists at a tertiary care center for opinions.
Telepsychiatry	Synchronous	Patients in a primary care setting are interviewed by psychiatrists at a tertiary care center over videoconferencing links for psychiatric assessment.
Teleradiology	Asynchronous	Radiographic studies (e.g., X-ray, CT, MRI) are digitally captured and sent over high bandwidth lines to remote radiologists for first or second opinions.

CASE DESCRIPTIONS

AlphaCare

AlphaCare inherited its telemedicine program from the early initiatives of one of its members, Alpha-A. During the 1960s, Alpha-A pioneered telemedicine. However, when government grants were discontinued, the program could not sustain itself and interest waned. Interest in telemedicine didn't develop again until the late 1980s when advances in telecommunications and digital image capture and storage technologies allowed efficient storage and transmission of radiological images. Dr. Turner, the chief radiologist at Alpha-A, started a teleradiology project, RADCARE, in an attempt to use these new technologies to reduce film storage costs and sell their radiology expertise to remote locations. According to Dr. Turner, one of the challenges was to manage the transition to a new way of practicing radiology. Using RADCARE meant "converting the work process of the first 100 years of radiology into a totally different work process." Instead of viewing films on a light-box, radiologists would have to view digitized films on a computer screen. Acceptance of RADCARE by radiologists was crucial since "the most expensive component of a telemedicine system is the physician."

Dr. Turner selected his project team members from young and enthusiastic radiologists who were advanced users of medical imaging technology. The team started off by demonstrating a commercial picture archiving and communications system (PACS) to other radiologists in the hospital. Radiologists found the PACS difficult to use, too slow in displaying images, and poor in image quality. They were highly concerned about the image quality because poor quality could lead to incorrect medical diagnoses. They were also concerned that slow response time would reduce their efficiency. Consequently, they preferred viewing films the old way — on a light-box. The project team learned from this experience that the system had to maintain spatial and contrast resolution of films, provide a very simple user interface, and display requested images within a few seconds. Dr. Turner also believed that his team should do rigorous scientific studies to prove to themselves and to the larger medical community that digital images do not compromise diagnostic accuracy. These studies were necessary to address scientific and ethical concerns about the quality of digital images.

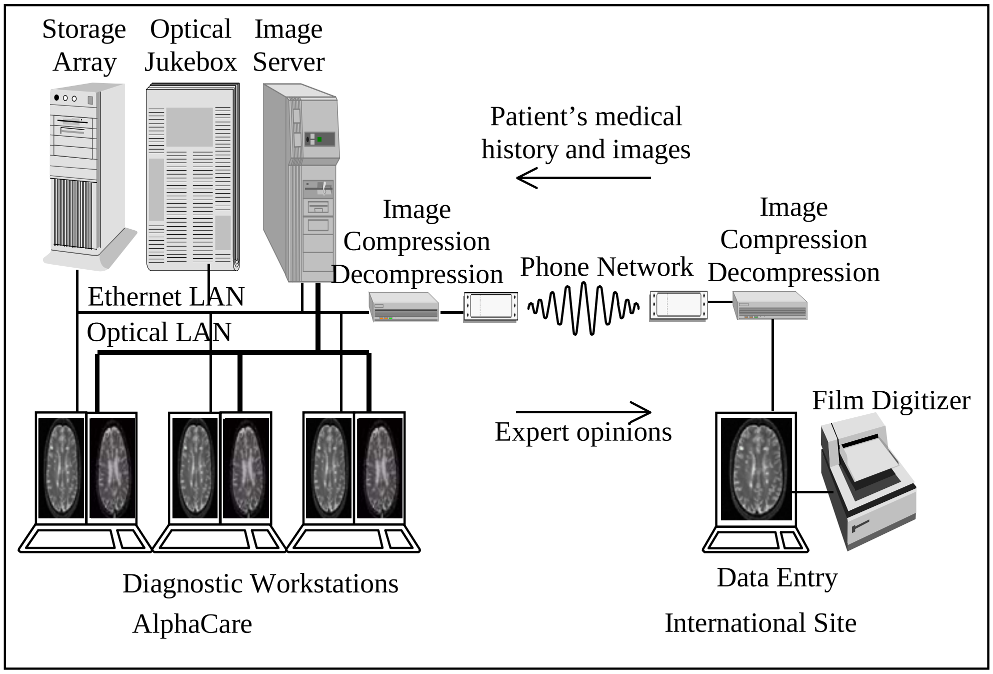
In order to address the technical challenges and develop a system that would satisfy the radiologists, the project team collaborated with the IS department, a local phone company, the MIT Media Lab, consultants, and several vendors. They used cutting-edge technologies such as film digitizers, an optical jukebox, high-resolution workstations, image servers, an Ethernet LAN coupled with a fiber optic LAN, and a bridge to interface with remote sites over T-1 [1.54 Mbps] lines. It took them about three years to develop the system. According to Dr. Turner, most radiologists were happy with image quality, response times and the system's ease of use.

The next step was to convince physicians, through a rigorous study, that the system does not compromise diagnostic image quality. The team conducted a study that showed a 98% concordance rate between interpretations of plain films and the corresponding digitized films on the RADCARE system. Dr. Turner reported, "All of the radiologists saw that they could interpret images off the workstation accurately, and we were able to begin inviting more and more radiologists to take part in teleradiology."

At the time, many radiology departments were losing revenue due to Medicare payment cutbacks. Radiologists saw RADCARE as an opportunity to generate new sources of revenue. Dr. Turner stated, "teleradiology was seen as a way of importing work into the department." However, they did not know how to commercialize RADCARE. After discussions with physician organizations at Alpha-A, Dr. Turner decided to spin-off two subsidiaries. One of them would further develop and commercialize the RADCARE system. The other, WeCare, would make a service business out of RADCARE by selling radiology expertise of Alpha-A to remote locations.

One of the challenges for Dr. Turner and WeCare was to explore and develop markets for teleradiology. In domestic markets, there were many regulatory barriers such as the prohibition of telemedicine across state lines and limited reimbursement for consultations. However, international markets (e.g., the Middle East) were relatively free of regulation. Moreover, affluent patients in

Exhibit 4: International Telemedicine at AlphaCare



international markets were willing to make out-of-pocket payments for high quality telemedicine consultations. Dr. Turner and WeCare discovered an enormous potential for international telemedicine: international sites had a hunger for world-class medical expertise not only in radiology but also in other medical specialties. Dr. Turner was surprised to uncover such a demand for pathology expertise and convinced the pathology department to develop a system for doing international telepathology.

However, there was a serious technical barrier for doing telemedicine with international sites. Many international sites lacked high bandwidth T-1 (1.544 Mbits/sec) or T-3 (45 Mbits/sec) lines required by the RADCARE system. In order to exploit the market potential, Dr. Turner had to find a way to run RADCARE over low bandwidth plain ordinary telephone (POT) lines. Running RADCARE over the POT lines could be possible through compression of images. Thus, the radiology team undertook a research study to find appropriate compression techniques for compressing and decompressing radiographic images. By applying a wavelet-based compression technique, they were able to achieve an average compression ratio of 23:1. The results of the study were published in a radiology journal.

In the meantime, the pathologists had developed a telepathology system. Dr. Turner and his colleagues wanted to demonstrate that the systems could run over POT lines without compromising diagnostic quality of images. Alpha-A and WeCare demonstrated the two systems between, first, the U.S. and Saudi Arabia, and, then, the U.S. and the United Arab Emirates. The demonstrations showed that compression did not degrade diagnostic quality of radiographic images. The resolution of pathology images was also good. A study was published in a radiology journal as the first successful use of POT lines for international telemedicine. Exhibit 4 illustrates the configuration of the international telemedicine application.

All medical specialties which rely on radiographic images for diagnoses could now use RADCARE to sell their expertise to international sites. Within six months, WeCare linked eight international sites to Alpha-A via RADCARE. By March 1995, Alpha-A had conducted 750 consultations in radiology and 150 consultations in other medical specialties.

The next challenge was to mobilize more physicians to get involved in telemedicine applications and consultations. The publication of scientific studies about RADCARE and the revenues generated from international consultations helped to increase physician interest in telemedicine. Having seen the success of teleradiology, the chiefs of the dermatology and psychiatry departments started research projects to assess whether and how telemedicine could be used in their own specialties. In the meantime, Dr. Turner was encouraging interested physicians to come together informally to talk about telemedicine. Over time, informal interactions among these physicians lead to the emergence of an ad-hoc telemedicine committee. This committee oversaw further development of telemedicine at the hospital.

In early 1995, Dr. King, a young dermatologist leading the teledermatology research, took the helm in the committee. The thriving international telemedicine business needed organizational support. The committee created three new positions: telemedicine coordinator, teleradiology coordinator, and teleradiology director. Operational procedures were developed for triaging incoming cases to physicians and ensuring that cases were turned around within set time limits. The committee invited other physicians to participate in order to meet the growing demand from international sites. Physician response was positive; they were able to earn consultation fees and gain access to intellectually challenging medical cases from around the world.

As the volume of consultations grew, it became clear that telemedicine would need better institutional support. Thus, the telemedicine committee prepared a strategic plan. In fall 1995, Alpha-A administration accepted the plan, approved establishment of a Telemedicine Center to streamline international telemedicine operations and to explore new telemedicine applications. Dr. King was appointed as the director of the center. After about a year, the CIO offered to make the Telemedicine Center a sub-unit of the IS department. He envisioned that telemedicine would be part of daily medical practice by the year 2000. According to Dr. King, this decision by the CIO moved telemedicine from being on the "lunatic fringe" to becoming an integral part of mainstream IS at Alpha-A.

In order to institutionalize telemedicine, the Telemedicine Center established departments to manage telemedicine operations, to conduct R&D on new telemedicine applications, to identify standards for telemedicine, and to explore remote education possibilities. It also established two telemedicine committees, the Alpha-A Telemedicine Committee and the AlphaCare Advisory Committee. Membership in the center and committees grew. A center manager commented on the Alpha-A Committee, "It is one of the very few committees that I have seen in my life that actually grew in time as opposed to turning inactive …." A research assistant reported, "At this center, every single department that we have is growing…."

As of May 1997, teleradiology was used routinely in domestic and international markets. All 65 radiologists were using the system to conduct about 3000 consultations annually. In other medical specialties, forty physicians out of a total of 400 were using international telemedicine to conduct about 400 consultations annually. Some specialties were less successful in developing telemedicine applications, however. In telepathology, pathologists were having problems with transmitting rich images within bandwidth constraints. In teledermatology and telepsychiatry, a number of studies had been published that clearly demonstrated that medical diagnoses were not degraded and that the technology worked in practice. Dr. King reported, however, that these applications were not deployed because they hadn't yet been shown to be profitable, "It [teledermatology] has to make sense either through a capitated model, or through a fee-for-service model. Currently, there are not either… So, it hasn't become part of the day-to-day for the [dermatology] department…." A telepsychiatry researcher reported, "In general, the problem for everyone today is proving cost-effectiveness…." The telecardiology application had been used only sporadically because cardiologists perceived that the amount of information they get from digital images is less than what they get from video tapes, which have traditionally been used to record echocardiography procedures. A cardiologist leading the teleradiology application commented, "So, they don't trust the technology… It is very hard to get physicians to change. That has probably been the biggest problem I have had… What it really takes, I think, is that you have to actually show them that this [telecardiology] does actually enhance evaluation of patients." Thus, he decided to conduct a research study to prove that telecardiology does not degrade the diagnostic content of echocardiography procedures.

By May 1997, AlphaCare was undertaking R&D on several new applications and was rolling out 25 videoconferencing units to its members. Dr. Turner commented on the evolution of telemedicine at AlphaCare, “AlphaCare is not an entrepreneurial innovative organization. It is very conservative. It is not going to get into a new concept or a new area like telemedicine as a leap of faith. The way AlphaCare is going to come into telemedicine is through the grass-roots interests of the younger, creative doctors and scientists in the system. We will be experimenting, testing, developing applications. As they mature, the business case can be made and we can get them implemented.”

BetaCare

BetaCare became involved in telemedicine in 1990 when it received a grant from the local phone company to develop a telecardiology application for testing a new wide area fiber-optic network known as media broadband services (MBS). The CIO at the time and the chief of cardiology led the development effort. The idea was to exchange angiography images with remote locations using the MBS. The application would enable physicians to interact on-line through a voice channel with a capability to annotate on the exchanged images. The current CIO commented on the system problems, “It was big UNIX workstations with a T3 pipe [45 Mbps] to do cardiac angiography. It never worked! It was incredibly expensive! And it quickly missed the key point that nobody can afford a $75,000 system plus $2000-$3000 a month worth of network charges in the health economics environment today.”

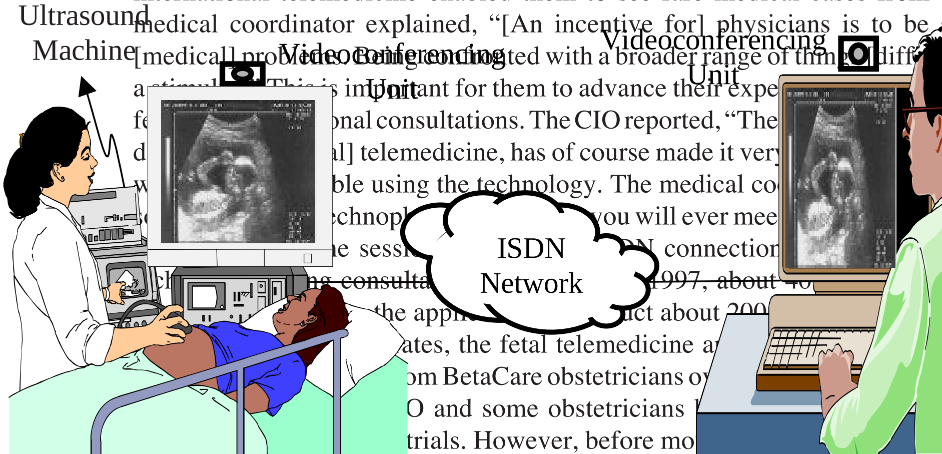
BetaCare learned from this experience that telemedicine solutions must be affordable if they are to be used widely in the hospital. The CIO went on, “In managed care, telemedicine has a very important role… [But] it is only there to solve specific problems, and it only makes sense if it solves them in a way that saves money and improves outcomes.” The IS department partnered with an engineering firm to explore low-cost, standards-based telemedicine solutions. The technical telemedicine coordinator reported, “The idea was to make it [telemedicine] cheap enough so that experiments can be done without huge pockets of money.” In six months, members from the IS department, the cardiology department and the engineering firm developed a desktop videoconferencing system that could digitize cardiac images off of angiography machines, compress them and send them to remote locations off-line as multimedia electronic messages. The new system was less expensive, standards-based, and required less bandwidth since it exchanged images off-line. However, it still ran on the expensive MBS infrastructure. The next challenge was to find cheaper ways of exchanging images.

The CIO explored the use of ISDN technology to meet their transmission needs at affordable costs. Tradeoffs between bandwidth and image quality were found through trial and error. The CIO asked several senior physicians to judge the quality of images for different bandwidths. When image quality was not satisfactory, more ISDN lines were used to increase bandwidth, and hence, the quality. For example, physicians were satisfied with the quality of details on an X-ray image achieved over a 128Kbps line. Psychiatrists, on the other hand, preferred to use a 384Kbps line when interviewing psychiatric patients in order to see them more clearly.

The CIO at BetaCare reported that unlike AlphaCare they did not normally undertake research studies to assess the quality of images or whether medical diagnoses were degraded or not, “We have never seen this [telemedicine] as a research project… [I]t is just part of our business.” Their first priority was to make a business out of telemedicine. They did not see image quality as an important issue. The CIO reported, “I have never had one doctor ever complain about quality.”

In early 1995, the CIO started demonstrating the system to the chiefs of clinics because “they were the guys who can make the correct decision [for their clinical telemedicine applications].” Many chiefs of clinics wanted to use the system to gain access to new patient markets. The CIO worked with them to conceptualize specific clinical telemedicine applications. He reported on the role of the IS department in this process, “We identify clinical needs and develop a business model.” The IS department and engineering firm customized systems for telecardiology, international telemedicine, teleophthalmology, telepsychiatry, nursing home, home health, and fetal telemedicine applications. Each clinic was expected to pursue its own application. The CIO reported, “We have never tried to make telemedicine an institutional program…. There is no hospital-wide ‘telemedicine budget’ at BetaCare. Each department decides if telemedicine would work for them, and if so, if it can be worked

Exhibit 5: Fetal Telemedicine at BetaCare



into their budget."

Initial trials showed that the business models envisaged for telecardiology, teleophthalmology, telepsychiatry, nursing home and home health applications could not generate reimbursement for consultations in domestic markets. Therefore, the chiefs of these clinics decided to discontinue the applications. However, all clinics continued to participate in international patient consultations. Physicians were motivated to participate in international telemedicine for two reasons. First, international telemedicine enabled them to see rare medical cases from around the world. The medical coordinator explained, "[An incentive for] physicians is to be stimulated by difficult [medical] problems. Being confronted with a broader range of things [difficult medical problems] is a stimul[illegible] This is important for them to advance their expe[illegible]hey were able to collect fe[illegible]onal consultations. The CIO reported, "The [illegible] making so much money d[illegible]al] telemedicine, has of course made it very [illegible]vever, many physicians w[illegible]ble using the technology. The medical co[illegible]nented, "Physicians are [illegible]echnop[illegible] you will ever mee[illegible]d medical coordinators [illegible]e sessi[illegible]N connection[illegible] physicians to use the ch[illegible]ng consulta[illegible]1997, about 40 [illegible] (or 10% of the total at [illegible] the appli[illegible]uct about 200[illegible]nsultations annually.

[illegible]ates, the fetal telemedicine a[illegible]ients at remote sites to [illegible]om BetaCare obstetricians o[illegible] links without having to [illegible]O and some obstetricians [illegible] the profitability of this [illegible]trials. However, before mo[illegible]o clinical use, they had to show to the national society which accredits fetal telemedicine sites and the insurance companies which reimburse consultations that medical diagnoses were correct and that fetal telemedicine was cost-effective. Even though the CIO did not see the value of scientific studies, the physicians believed studies were necessary. One obstetrician reported, "The studies that we did to validate telemedicine have provisionally been accepted for two of our journals." They began to define how a typical fetal telemedicine session would be conducted. There were two possibilities: 1) on-line video connections; or 2) off-line image storage and transmission. Each had different implications for the daily routine of the clinic, the volume of cases that could be served, staffing requirements, and cost-effectiveness. One obstetrician commented, "We have to do traffic-flow type of studies before we can say whether it is cost-effective." As of March 1997, all eleven physicians in the clinic were using the application. They were conducting about 1000 consultations per year in their research studies. They expected the volume to grow dramatically when the application is moved from research into regular clinical use.

GammaCare

The telemedicine program at GammaCare is an extension of an early program developed by one of its founding members, Gamma-B Network. In early 1994, Gamma-B realized that its use of resources and methods of patient referral across its member institutions were inefficient. Due to a lack of appropriate expertise, the community hospitals were spending too much time and resources on difficult patient cases that could have been dealt with in a faster and more cost-effective way at their teaching hospitals. Under increasing pressure from managed care and capitated payment systems, Gamma-B began looking for ways to increase its operational efficiency.

In mid-1994, Henry, the head of media services, proposed to link member institutions via telemedicine (using videoconferencing technology) to enable “a seamless integration of care so that wherever the patients happen to be, they are part of the [Gamma-B] system.” With the support of the CIO, a vice president and some physicians, he prepared a business plan that outlined a phased implementation starting with demonstrations of telemedicine between two hospitals and then expanding into all member institutions. The administration accepted the plan, provided funding for exploration of the technology, and appointed Henry as the telemedicine project manager.

In early 1995, Gamma-B acquired two group videoconferencing systems. Henry convinced a staff member of media services and a young cardiologist to serve as the technical and medical telemedicine coordinators. He also secured technical support for telemedicine from the IS department, but it was mainly limited to installation and maintenance of ISDN lines. Unlike AlphaCare and BetaCare, GammaCare did not get involved in the development or modification of telemedicine technology. Instead, it has tried to apply commercially available videoconferencing systems to their proposed applications. As champions of telemedicine, Henry and his technical and medical coordinators tried to raise awareness of the technology across the organization. They identified physician champions and site coordinators at member institutions, and provided them with administrative and technical support. They exposed physicians to the technology through demonstrations, and educational and administrative teleconferences.

Early adopters of the technology included a world-famous liver transplant surgeon at the academic medical center, two site coordinators at a community hospital, and a few young physicians. Two hospitals were linked in early 1995. Physicians at the community hospital now had access to educational tumor conferences at the medical center via teleconferencing. They conducted about 30 such tumor-board conferences until mid-1996. The surgeon also provided a few (3-4) consultations to patients at the community hospital by reviewing their X-rays and interviewing them over the video link. This application was called “rare tumor consults” since the surgeon specializes in rare tumors. The surgeon reported, “I look at this as really an incredible way to interview patients, look at their films, talk things over with them.” Although he receives seven to eight rare tumor cases per week from around the world, he cannot use telemedicine since the referring physicians lack access to the technology.

In mid-1995, the community hospital lost its cardiology coverage. Third year fellows from the academic medical center commuted to the community hospital to cover emergency and intensive care units (ICU). These young, computer literate physicians used the technology to exchange X-rays, MRIs, echocardiography, etc. with the medical telemedicine coordinator at the ICU of the medical center. The president of the community hospital reported, “They were using the technology like the telephone… ‘Here look at this, look at that, OK? I am going to send you the echo! Here is the EKG strip!’” They conducted about 30 to 40 ICU-to-ICU consults. The coordinator expressed satisfaction with the technology: “By and large, major decisions can be made using the current technology.”

Another member teaching hospital soon acquired a videoconferencing unit and connected to the telemedicine network. Anesthesiologists, technicians, and nurses from the two teaching hospitals started doing teleconferences to conduct their regular educational and administrative meetings. They conducted about thirty such meetings.

The feasibility of conducting pre-surgery interviews with patients over videoconferencing was tested. This application would enable patients to go to the nearest member institution for their interviews, thus, enhancing the completion of interviews and reducing costly surgery cancellations. Nurses interviewed two mock-patients at the community hospital. Although they were happy with the video interviews, they stated that incorporating telemedicine into their daily routines would be a challenge: "You couldn't just have so many [video] calls up in the middle [of serving patients here]." Cost-effectiveness of the application was not clear. The technical telemedicine coordinator reported, "At this point, we have not proved that [it] pays."

In summer 1996, Henry and coordinators evaluated their experiences, prepared a phase-II business plan, and put together a telemedicine executive committee. After two years with telemedicine, Henry reported that most physicians saw telemedicine as a "toy" rather than a clinically useful technology: "[T]he easy part is the technology… The much tougher part is really getting people to collaborate together on a regular basis, not just to play around with the toy but to do work together…." A site coordinator reported, "[Telemedicine] is still a technology that people are leery of in terms of how it can be used and how valuable it is."

Henry recognized challenges in making telemedicine work: "[I]t is really easy to do administrative applications…. Educational is also fairly easy…. But, clinical stuff is much more complex: You have to deal with reimbursement; you have to deal with clinical care; you have to deal with patients; you have to deal with physicians; you have to deal with infrastructure; you have to deal with..., you name it!" He described the next step: "We need to show [physicians] the real solutions as opposed to demonstrations…."

However, the telemedicine initiative started to drift in October 1996 when the academic medical center of Gamma-B merged with another academic medical center in Boston. During the merger turmoil, some physicians left the institution while others were busy with changes brought about by the merger. Teleconferences came to a complete halt. Henry spent this period expanding the telemedicine network to the remaining community hospitals. The initiative started up again in early 1997 with monthly meetings of the telemedicine committee.

CURRENT CHALLENGES/PROBLEMS

The extent to which telemedicine has diffused varies across the three sites. Diffusion was relatively high at AlphaCare. Teleradiology and international telemedicine applications were regularly used, had high volume consultations, and the number of physicians using them was increasing. At AlphaCare, the champions of telemedicine were physicians. Their grassroots efforts played an important role in making telemedicine part of mainstream IS and diffusing telemedicine applications throughout the hospital. They learned how to develop technically feasible telemedicine applications *de novo* in collaboration with the IS department and various external organizations. They proved the medical validity of their applications through scientific studies and developed business models that could generate reimbursement. Technically feasible, medically valid, and reimbursable applications engendered adoption and usage by more physicians and prompted the original champions to develop institutional support mechanisms for telemedicine. Future challenges for AlphaCare include showing cost-effectiveness for teledermatology and telepsychiatry; lowering physician resistance to telecardiology; further developing telemedicine business in international markets; and demonstrating that telemedicine could reduce costs and improve quality of care within its IHCN. Although they were happy with the achievements to date, Dr. Turner and Dr. King thought that the real potential of telemedicine would not be realized until all applications were integrated into one system. At the conclusion of the case study, they were wondering how this integration could be achieved across the organization.

At BetaCare, diffusion was moderate. International telemedicine was in regular use, but the volume of consultations was lower than that of AlphaCare. Fetal telemedicine was taking off, but there were organizational and economic barriers to its widespread deployment. One of the challenges was to decide whether real-time or store and forward type of consultations would be more efficient and cost-effective for BetaCare. Another challenge was to demonstrate the medical validity of the fetal telemedicine application to insurers and regulators. In other application areas, such as telecardiology and telepsychiatry, usage was sporadic because profitability was yet to be shown.

BetaCare learned how to develop technically and economically feasible telemedicine applications by collaborating with an engineering firm. The CIO tried to diffuse the applications through a top-down approach of convincing various clinic chiefs of their usefulness. Under his guidance, BetaCare did not routinely undertake scientific studies. However, some physicians were beginning to understand the importance of scientific studies in convincing the external medical community (e.g., insurers and regulatory agencies) of the medical validity of their proposed telemedicine applications. Only the most economically promising applications were currently being considered for clinical use. At the end of the case study, the CIO was concerned about developing appropriate business models for the various applications and whether they could integrate telemedicine into the routines of the clinics.

At GammaCare, diffusion was low. At the end of two years, there was no active telemedicine application in use. Although the technology was being used for educational and administrative teleconferences, it had not yet diffused into medical practices. Physicians saw telemedicine as a nice "toy" rather than a clinically useful technology. At GammaCare, the telemedicine initiatives came from the media services department which focused primarily on promoting the technology rather than figuring out how it might be integrated into specific medical practices. Unlike AlphaCare or BetaCare, GammaCare did not engage in technology development or modification. Instead, it implemented commercially available technologies. The telemedicine program at GammaCare lacked innovative physicians who would develop new telemedicine applications or do telemedicine research. The involvement of the IS department was limited to technical support for the ISDN infrastructure. However, the telemedicine initiative was starting up again in early 1997. The primary challenges for GammaCare were to involve innovative physicians in its telemedicine program, develop clinical telemedicine applications, and demonstrate the value of these applications to its medical staff. At the end of the case, Henry was pondering how best to address these challenges based on the experiences they had gained in the last two years.

Telemedicine champions at AlphaCare, BetaCare, and GammaCare were aware that telemedicine is one of the keys to the survival and success of their organizations in the changing healthcare environment. However, exploitation of the opportunities offered by telemedicine depend heavily on its widespread adoption and use by physicians. Ad hoc demonstrations and experimentation with commercially available systems are not sufficient to convince physicians to routinely use telemedicine applications. The champions wondered how they could make telemedicine part of the daily life of more physicians in their hospitals.

NOTES

[1] The contents of this manuscript are the opinion of the authors, not of the National Science Foundation or the U.S. government.

[2] Pseudonyms have been used to disguise the names of all organizations and individuals.

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