

Evaluating Telemedicine Technologies in Rural Settings

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Changes in health care policies, demographics, and technology have presented new opportunities for the delivery of medical care services and information to rural communities. Telemedicine—the use of electronic information and communications technologies to provide and support health care when distance separates the participants—has significantly impacted the delivery of rural health care services. This paper presents an overview of the telemedicine technologies, government involvement in support of telemedicine, and issues that need to be addressed in designing an economic framework to evaluate the net benefits of telemedicine to rural communities and consumers.

Federal and state governments have invested millions of support dollars in the form of equipment, infrastructure, and incentives for consumers and providers to expand the use of telecommunications in medical care. Since disbursement of these funds is already underway, it only makes sense to develop a method to determine both where and whether an additional dollar of funding for telemedicine development would be of the greatest benefit to society. If telemedicine can prove itself as a useful method for improving the likelihood of survival of rural hospitals, then, in the interest of rural development, it may be a technology worth investing in; i.e., the social benefits, measured as the sum of the private and public benefits, may outweigh the costs.

According to its supporters, telemedicine systems have the potential to simultaneously address several problems characteristic of health care in rural areas, including access to care, cost containment, and quality assurance. Access can be improved by linking providers in remote areas with specialists in metropolitan centers or peers in rural areas. Telemedicine not only enables a wider range of services to be offered in the local community but may have the added effect of improving physician retention in isolated areas, one of the primary challenges in maintaining access for frontier medical centers. Telemedicine can promote cost containment through the substitution of lower-cost rural providers and facilities. Ideally, improved quality will be achieved by the ready availability of consultations and referrals. These are the potential benefits of telemedicine implementation, but they have not yet been verified by research in a field setting.



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An evaluation framework for telemedicine needs to be capable of modeling changes in the behavior of health care consumers (i.e., altered visitation patterns), recognizing differences in quality of service, and finally, quantifying the value of these changes. This is no small task, and obtaining the required data will likely require the cooperation of many parties, including health care providers, patients, hospital and program administrators, and policymakers. These are the same groups that could benefit greatly from a better understanding of how telemedicine technologies affect health care delivery, but a meaningful framework for analysis needs to capture the many aspects of telemedicine implementation.



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Over the past decade, changes in health care policy, demographics, and technology have presented opportunities for new types of medical care delivery. Telemedicine is one example of a technology application that has begun to change the way health care facilities do business. Economic evaluation of telemedicine technologies is useful to health care policy makers in order to better understand how telemedicine implementation affects the dynamics of rural health care.

Telemedicine is defined here as *the use of electronic information and communications technologies to provide and support health care when distance separates the participants*. With every new health care innovation comes the challenge of determining whether the additional benefits outweigh the costs and whether public support in the form of direct funding, Medicare reimbursement, and subsidy for the developing technology is justifiable. From an economic perspective, the issue is multidimensional: key considerations include how the technology will affect health care *quality, access, and cost*, and the tradeoffs among them. To make this determination, relevant costs and benefits must be correctly identified and measured. Applying economic methods to the valuation of telemedicine systems is a first step toward understanding the effects of implementation on communities, health care facilities, and consumers.

Experience with telemedicine is limited, and although its emergence has been met by some with enthusiasm, efforts at determining the benefits and costs are very recent. Difficulties are also encountered when obtaining, classifying, and identifying standardized data sets from ongoing telemedicine programs:

“Telemedicine is difficult to track because no one in the industry has the whole picture, and no agency is monitoring its growth. There is no medical board requirement, no special license needed, no FCC approval, no institutional or individual credentialing at the state level (cross-state licensure, liability laws and the development of industry standards may one day change this)” (Association of Telemedicine Service Providers 1998).

This paper presents an overview of telemedicine technologies which is a prerequisite for the design of a framework for evaluating the impacts of telemedicine technologies in rural settings. Information is provided on the extent of telemedicine usage, government involvement and support, and telemedicine evaluation efforts to date. The paper introduces an economic evaluation framework, focusing on issues that need to be addressed in quantifying the benefits of telemedicine to rural communities.

Telemedicine is changing the way health care is delivered in many rural communities.

The overall effect of telemedicine on hospitals, communities and individuals is unknown.

Often, analysis of telemedicine has been limited to its effect on the financial position of the hospitals involved and the clinical effectiveness of its procedures (Preston 1995; Siwicki 1997). Although these are certainly important issues, they constitute a very narrow view for determining the full value of the technology. It is important to remember that telemedicine is not so much a product in itself as it is a method for delivering the product of health care. It then becomes clear that the value of telemedicine, especially in rural areas, must be determined in part by observing how it affects the behavior of consumers: does telemedicine alter where and how often residents seek care?

Another element in quantifying the net benefits of telemedicine is the valuation of the overall contribution that telemedicine makes to the viability of rural health care services in a given community, which can, in turn, affect access to care. Whether telemedicine enhances the quality and level of health care services in a rural community or whether it contributes to a decline in locally available services due to increased competition from tertiary centers operating the telemedicine networks is an empirical question. Thus evaluation efforts require a well-designed analytical framework that identifies all potential direct and indirect benefits and costs.

Changes in Rural Health Care

One of the observable characteristics of change in the underlying structure of rural health care is the increase in rural hospital closures. During the 1980s the closure rate for rural hospitals doubled to 10 percent compared to earlier decades (American Hospital Association 1992; 1989). The health care literature commonly cites several factors that influence this situation, including changes in rural demographics, difficulty in physician retention, and the restructuring of Medicare reimbursement (Gaumer et al. 1992). The demographic shifts and declines in rural population have resulted in a disproportionate number of elderly people in rural areas. An additional issue often encountered by small and isolated community hospitals is physician recruitment and retention. The difficulty in attracting and retaining physicians in low-volume facilities compounds the challenge of keeping a small hospital open.

Another significant factor usually noted as a key change for rural health care is Medicare policy change with regard to the reimbursement of health care facilities, from a cost-based reimbursement to a Prospective Payment System (PPS). Under the PPS, smaller rural facilities commonly fail to cover costs on Medicare patients (Komisar 1991; ProPAC 1994). This, in combination with the fact that rural hospitals serve a proportionately greater elderly and low-income population than their urban counterparts, has contributed to a financial crisis for many rural hospitals.

The actual and potential loss of hospitals has left rural citizens with a very different health care scene than in years past. Faced with these realities, the health care system has developed new delivery methods. In Montana, two innovations have come about as a result of this rapidly changing rural health care environment: (1) the appearance of new types of rural hospitals

focusing on cooperative agreements among facilities and exhibiting a limited-service philosophy, and (2) a more widespread use of telemedicine.

The Critical Access Hospital (CAH) program came into existence as part of the 1997 Balanced Budget Act. One of the predecessors to the CAH was the Medical Assistance Facility (MAF), an effort by small Montana hospitals focused on maintaining limited-service facilities by requesting cost-based reimbursement and increased responsibility of mid-level providers. Length of stay is restricted as a mechanism for focusing the services of the hospital toward emergency and acute care.

The 1990s has seen a dramatic rise in the number of telemedicine networks serving rural communities. The trend suggests a perception that by joining forces with a larger hospital, a rural facility can increase its chances of survival. The opportunity for the rural hospital exists in the expansion of its scope and quality of services and in possible increased cost-effectiveness in providing existing services. The advantage to the central hospital is its widened referral base. Decreasing costs and higher-quality equipment have made all types of telemedicine systems more commonplace than at any previous time. This, in combination with changes in the organizational arrangements for hospitals, clinics, and insurance companies, provides a much wider set of options. The increase in technological networking has opened some doors, but at this point it is difficult to know where those doors might lead.

Historical Perspective

The earliest use of medical telecommunications occurred in the 1950s, when the first successful trial of teleradiology was completed. The University of Nebraska at Omaha used two-way closed-circuit television in the transfer of patient information to medical students and tested interactive video conferencing in mental health consultations. In another program, Native Americans received medical exams using a specially equipped van and two-way microwave communication to transmit radiographic and electrocardiographic images. The experiments of the day were often technology driven as opposed to shifting the focus of implementation to the level that would best serve health care needs in a community. When further federal funding could not be obtained, many of the telemedicine projects ended in the late 1970s (Crump and Pfeil 1995). According to a special report published in the *Journal of the American Medical Association*, with the exception of a single telemedicine program at Memorial University of Newfoundland, St. John's, none of the programs started prior to 1986 were known to be in operation in 1995 (Perednia and Allen 1995).

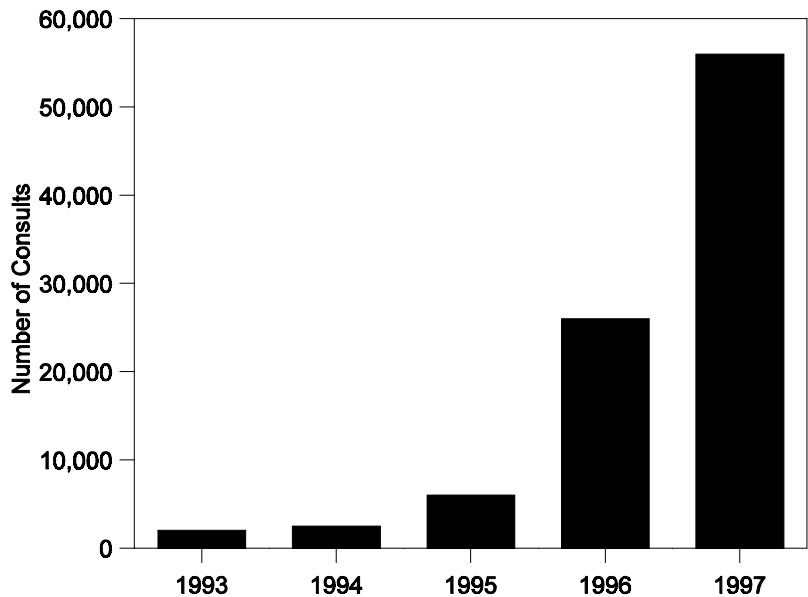
A number of factors contributed to the revival or development and implementation of telemedicine programs that began in the late 1980s. Technological advancements enabled interactive video transmission over certain types of telephone cable, significantly cutting transmission cost. Additionally, the growing presence of managed care and physician-hospital alliances brought health care to a new level of competition. These factors,

Widespread hospital closure led to innovation in rural health care delivery.

combined with mandated access to care and increased provider risk with regard to patient outcomes, prompted the reintroduction of telemedicine (Perednia and Allen 1995).

According to the Association of Telemedicine Service Providers (ATSP), the number of telemedicine consults has increased dramatically, rising more than twentyfold in five years (see Figure 1). A consult refers to a use of the telemedicine network for a specific patient-provider interaction or a provider-provider interaction. The numbers reported in Figure 1 represent a lower bound on the actual number of consults since only 97 programs of the nearly 150 telemedicine programs contacted responded to the survey. The single greatest use of telemedicine reported in the ATSP survey was for radiology. During 1996 and 1997 teleradiology and clinical drug trials accounted for nearly 50 percent of all reported consults.

Figure 1. Consults Reported by U.S. Telemedicine Programs, 1993–1997



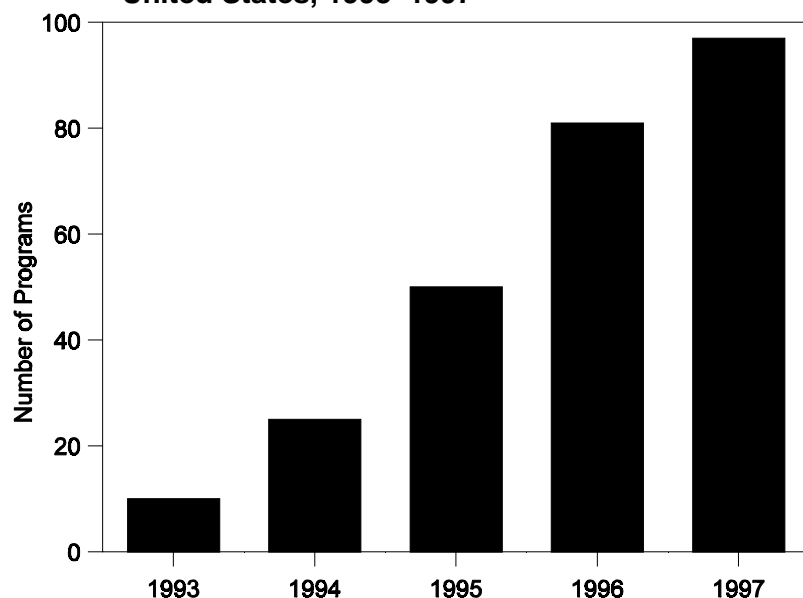
Source: ATSP (1998)

Note: 1997 figure is projected from first quarter data.

Use of telemedicine has increased dramatically in recent years.

In 1997, the ATSP annual survey identified 97 active telemedicine programs in the United States (Figure 2). Aside from teleradiology and clinic drug trials, the most widely used specialty applications, according to the number of programs reporting some activity to ATSP, were: mental health, dermatology, cardiology, orthopedics, and emergency room/triage services. Other uses of the telemedicine networks included general surgery (follow-up procedures), pediatrics, pathology, nutrition, primary care and neurology. In total there were over 40 different categories of clinical specialties for which telemedicine technologies were being used.

Figure 2. Telemedicine Programs Reporting Activity in the United States, 1993–1997



**Telemedicine
encompasses a wide
range of technologies.**

Source: ATSP (1997) Telemedicine Report

Levels of Telemedicine Technology

In general, the term telemedicine refers to the use of telecommunications technology to enable or assist medical care when its participants are separated by distance. This connection could be achieved using any number of telecommunications technologies, though interactive video is the medium most commonly associated with telemedicine. The following are also telemedicine applications: POTS (Plain Old Telephone Service) for assistance with diagnosis and referral or check-ups for cardiac patients using remote stethoscopy; fax transmission for transfer of EKG and fetal heart monitor strips; use of personal computers in scanning databases for assistance with research and diagnosis; and electronic transfer of x-ray images and tissue biopsy through teleradiology and telepathology.

Although teleradiology is presently the most widely used type of telemedicine, interactive video is the focus of more current research and grant funding than any other application. Barriers to its use are its high fixed and variable costs in comparison to other technologies, as well as legal and regulatory ambiguities. However, it may offer a unique set of opportunities for health care since it can provide for real time audio and motion interaction between remote participants. Examples of this type of application most commonly include links between rural areas and more urban sites.

The level of specialized equipment, range of use, amount of employee training necessary, and objectives of the individual health care facility are all factors that enter into the decisions of whether to adopt telemedicine and what type to adopt. It stands to reason that differing levels of telemedicine technology may be appropriate for different health care situations or communities. Analysis of these decisions by health care providers and how

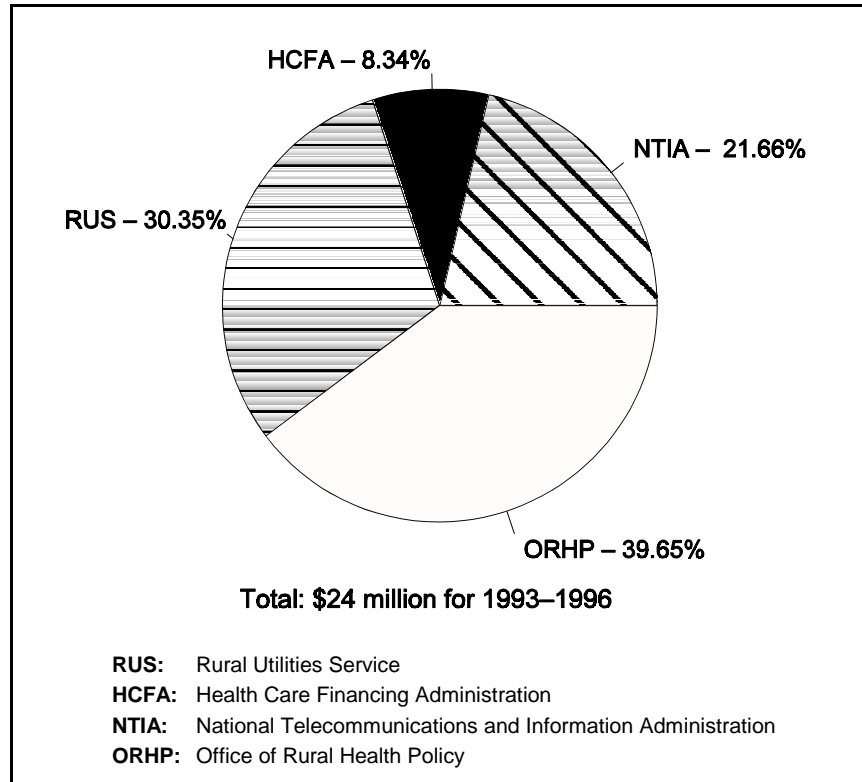
they affect both health care systems and consumers is a vital part of understanding the implications of telemedicine implementation.

Governmental Support Mechanisms

The federal government has played a large part in research and funding for telemedicine projects. Figure 3 provides some summary statistics on the levels and sources of federal funding for telemedicine in the United States.

Federal dollars have played a significant role in the initial development of telemedicine systems.

Figure 3. Selected Sources of Federal Funding for Telemedicine, 1993–1996



Source: Federal Telemedicine Gateway (1998)

The Telecommunications Act of 1996 established a Federal Universal Service Fund designed to provide telecommunications discounts and subsidies for schools, libraries, and rural health care providers. Under the act, some rural health care facilities and physicians are eligible to receive reduced rates for telemedicine transmission and Internet access. In essence, the law encourages development and use of two main types of telemedicine services, interactive video and physician use of Internet resources, by providing subsidization for long-distance rates. Mainly, the Telecommunications Act promises to substantially lower the cost of providing video interface for rural health care facilities. Connections between sites are made via high-bandwidth telephone cable, which results in very high variable costs to telemedicine programs, equivalent to constant multiple long-distance telephone calls.

Reimbursement is another area where federal health care policy greatly impacts the use of telemedicine. Teleradiology consults have been reimbursed by Medicare nearly since its development. However, interactive video consultations are generally not reimbursed by Medicare since present policy in many states requires a “face-to-face encounter between patient and provider.” This lack of physician reimbursement under the federal insurance plan is a significant disincentive for practitioners to become involved in video consultation.

A primary method of federal assistance for telemedicine programs is funding for the purchase of equipment and support. Most grants have been made available to purchase and support equipment for an initial period, with hopes that the network will become self-sustaining in time. Due to the fairly recent nature of these types of programs, there is limited information available regarding the present state of formerly federally funded telemedicine programs that have since become the responsibility of another entity. The proportion of such networks that come under state control as opposed to those that continue to operate by virtue of private industry or even dissolve completely without federal support has not been fully documented.

Federal dollars have been used to develop a number of committees to inventory, evaluate, and standardize telemedicine programs. One of the main oversight groups is the Joint Working Group on Telemedicine (JWGT). Activities of the JWGT have included a report to Congress on the use of advanced telecommunications services for medical purposes (Dept. of Commerce 1997) as well as an effort to inventory programs and identify federal spending for telemedicine. A website, the Federal Telemedicine Gateway (<http://www.tmgateway.org>), was established to convey this information. Additionally, in 1998 the U.S. Department of Health and Human Services established a new office directed specifically toward telemedicine activities. Responsibilities of the Office for the Advancement of Telehealth include policy and program development, assistance for health officials and grantees, and production of health education tools.

Telemedicine Evaluation Efforts

Existing research on telemedicine evaluation can be placed into two main categories: (1) financial justification/estimation and (2) clinical effectiveness. Within financial justification fall cost-benefit analysis and cost-effectiveness measurement. Clinical effectiveness studies cover a wider range of subjects all centering on finding out how well telemedicine systems work from a number of viewpoints. Subjects within this area include comparison of patient outcomes and development of quality measurement methods.

Two large-scale telemedicine evaluation research projects are currently under way. The Center for Health Policy Research, in cooperation with the Telemedicine Research Center, is heading up one of these projects. Objectives of this research, financed by the Health Care Financing Administration (HCFA) include development of policy for Medicare concerning utilization review and payment methods for telemedicine

No single entity has a full view of telemedicine development, making it difficult to track expansion and program longevity.

services. The study was designed to identify and track patients who use telemedicine technologies, obtaining information about medical outcomes, costs of care, and relevant demographic, historical, and clinical data. By comparing this information to results of a control group, the researchers hope to gain a better understanding of both cost-effectiveness and clinical outcomes when telemedicine is used in treatment.

Another ongoing research effort, also involving the Telemedicine Research Center, is sponsored by the Office of Rural Health Policy (ORHP). The project focuses mainly on 30 interactive video programs that are ORHP grant recipients and is developing methods of evaluation and data gathering for those programs.

Although there is no shortage of information regarding telemedicine evaluation in one form or another (Telemedicine Information Exchange 1998; Drummond et al. 1987), some important considerations have been ignored in studies to date. First, telemedicine is often treated as a stand-alone procedure and analyzed independently from the health care system. When viewed in the larger context of a regional health care system, the effects of telemedicine may vary significantly as compared to those found when it is viewed as an independent site-specific component. Furthermore, in measuring the benefits of increased use of telemedicine at a given location within a regional health care system, the possible substitution of health care services away from sites without telemedicine should be recognized as one potential effect of implementation.

Economic Framework for Evaluating Telemedicine Technologies

Benefit-cost analysis (BCA) provides the framework for assessing the welfare impacts of a change in the technology for the delivery of health care services. The benefits accrue primarily to the patient in the form of more readily available specialty consultations and reduced travel time. The costs are borne by the practitioners and their organizations, and unless the benefits to them outweigh the outlays made when participating in telemedicine consultations, continued physician support is unlikely. In light of this, although the total social benefit of telemedicine implementation may potentially be greater than the social costs involved, the incentive for physicians may be such that they largely forgo involvement in telemedicine altogether. Thus evaluation of telemedicine must take into consideration the effects of disparate distribution of costs and benefits between different parties, including patients, physicians, and taxpayers.

One of the most crucial factors for designing a BCA of telemedicine is the fact that uncertainty exists regarding the effect of telemedicine on the delivery of health care. For example, will consumers use a local facility that offers a telemedicine service or instead bypass the local facility to utilize the larger tertiary facilities? How sensitive are these decisions to distance and types of service needed? Factors that may influence the measure of benefits to society include whether telemedicine enhances quality of care and whether it gives rural hospitals a greater likelihood of survival.

**Economic evaluation
of telemedicine
remains limited.**

Although complex, this challenge is not unique to the evaluation of telemedicine. Uncertainty concerning the effects of technology has been addressed in other settings, including evaluation of new and emerging agricultural technologies and evaluation of net returns from publicly funded research (Alston, Norton, and Pardey 1995).

To quantify the benefits and costs of telemedicine, one needs to first conceptualize how telemedicine impacts the demand and supply of rural health care services. Our review of the literature suggests that telemedicine impacts can be categorized as follows:

(i) Telemedicine impacts the types of services that can be offered in rural communities. This is basically what we call the access question: Does telemedicine increase access to health care for rural residents, and if so, by how much?

(ii) Telemedicine impacts the quality of the services that are offered in rural communities. The literature is mixed on whether telemedicine increases or decreases the quality of a given service relative to the offering of that service prior to telemedicine. This seems to be an empirical issue and relates to the specific service being offered.

(iii) Telemedicine impacts the cost of providing or supplying a given level of health care services to a community.

The private and public good characteristics of rural health care, consideration of time and travel cost as a part of price, the discrete choice nature of the decision of where to seek health care, and allowance for varying levels of quality are issues in demand modeling for rural health care services that need to be explicitly recognized to the extent possible. Similar issues exist for quantifying the demand for recreational services, and thus the literature on modeling the demand for recreational services and other environmental goods provides a starting point for the development of a conceptual framework for modeling the demand for rural health care (see Capalbo 1999 and Heggem 1998 for further discussion).

Within this framework one can capture many of the relevant dimensions: consideration of health care services as being provided within a rural health care system, which includes many sites offering an array of different services of varying quality. The value of telemedicine services at a given site depends upon the characteristics of the system, such as distances to alternative sites, and the availability of the telemedicine option at alternative sites, as well as the usual demographic and income characteristics of the population. This specification argues for the use of a method that models the nature of the health care decision and the substitutability among quality-differentiated sites. The framework should also be capable of valuing the addition (or subtraction) of a new health care site to the rural health care network.

Telemedicine may impact the range, quality, and cost of services offered.

Measuring the social benefits of telemedicine means identifying both the private and public components.

An Illustration

Telemedicine implementation brings with it both societal costs and benefits. To illustrate considerations in the calculation of aggregate social benefits, imagine the decision of a federal agency concerning where to best award a grant for start-up of a rural telemedicine system. The finalists are prospective systems A and B, both with the same hub site and an equal number of rural connections. The primary difference between the proposed programs is population and distance between the respective sets of connected rural facilities and the hub site. Along with the number of area residents, there are also differences in the demographics of communities involved; for example, some have a high proportion of elderly residents. For simplicity, the prospective costs of both projects are equal. An effort should be made determine the recipient of the award partly on the basis of which option offers the greatest net social benefit to the rural communities, measured as the dollar value of benefits minus costs over time.

Both private and public benefits need to be included in this determination and subsequent comparison of the alternatives. Private benefits are those realized by individual consumers as a result of having telemedicine present. The size of these benefits is determined by such factors as distance to alternative care, the change in quality of locally available care, and the number of individuals affected. Additionally, there are public benefits to consider, including whether telemedicine enhances the viability of the hospitals that are components of the regional health care network. Part of this consideration is predicting the effect of telemedicine on patient behavior, since it is not clear that telemedicine will necessarily increase access to health care. If the introduction of telemedicine capability to one rural hospital contributes to the closure of another rural health care facility, then this decrease in access to health care services for the residents of the second community should also be considered as an effect of telemedicine implementation. In general, it is important to consider the health care alternatives consumers face when telemedicine is not available. This is then contrasted with likely behavior if the technology is implemented and potential benefits estimated accordingly. The savings, or averted costs, to individual residents of a remote community with few local health care options may be greater than to those in a more centrally located community. Simply put, it is more expensive (including both actual cost of travel and time away from work) to drive 200 miles to meet with a specialist for a check-up than it is to drive 50 miles. However, this must also be balanced with the number of individuals in each area and their health care needs, along with the effect of implementation on the relevant hospitals.

Our review of the existing information on telemedicine usage indicates that the data commonly collected provide an overview of the number and types of consults classified by site, length of time involved, number of professional personnel involved, and limited information specific to the characteristics of the patient such as income, occupation, and zip code. This type of information is collected by the Eastern Montana Telemedicine Network (EMTN), centered in Billings, Montana. Useful observations have been made in cooperation with EMTN regarding the overall trend of

telemedicine use in the network, and preliminary analysis has been conducted regarding the impact of location and population on usage rates. By making simplifying assumptions regarding single-purpose trips and lack of available substitutes, one can also provide estimates on the benefits of each telemedicine consult, measured as the cost averted by having a local care option available via telemedicine (Heggem 1998).

The Heggem study focused on the use of telemedicine for psychiatric consultations within the EMTN system and consisted of two parts: (1) quantifying averted costs for users of telemedicine sites, and (2) determining whether usage rates were positively correlated with distance from alternative care. Averted cost measures for individuals seeking psychiatric care were calculated using an average wage rate and under the assumption that the alternative to telemedicine consultation was traveling to Billings, where an in-person visit could have been conducted. In Montana, there are no practicing psychiatrists in the rural area of the EMTN, which includes much of the eastern part of the state. It was found that the magnitude of the benefits depended on distance from Billings and number of uses of the system (Table 1). In addition, it was found that as distance from Billings increased, use of the system also increased, which is what one would expect since those furthest from alternative care would seem to have the most to gain by using telemedicine.

Table 1. 1998 Averted Costs Measures for Eastern Montana Telemedicine Network Participants

Site	Distance from Billings	Number of Uses of System	Calculated Averted Cost
A	225	2	\$268
B	120	47	\$5,160
C	312	27	\$7,730
D	276	105	\$26,729
E	222	210	\$42,657
F	145	382	\$51,283
G	270	138	\$34,092

Source: C. Heggem (1998) *Rural Telemedicine: Issues and Methods for Benefit Estimation*

Although partial analysis is useful as part of the assessment of specific telemedicine networks, it is far short of data needed to address the larger policy questions regarding an efficient level of investment in rural telemedicine technologies. What is missing from currently available data is information on the “quality” of the consult, information on the number of patients who opted to not utilize the locally available telemedicine services, and demographic and health care histories.

To our knowledge, the data needed to estimate a behavior-based model of rural health care demand have not been collected. The type of data needed could be obtained at the household level from interviews with individuals

Telemedicine becomes more attractive as distance to alternative care increases.

who had recently sought medical care, and also with those who had chosen not to, in order to isolate and measure the impact of telemedicine. For each individual, information on demographics and income levels should be obtained along with the number and nature of health care visits. In addition, detailed information regarding the attributes of available health care sites is also needed, such as the procedures available, distances, and some quality measures, including number of physicians, capacity of the site, and program longevity.

Conclusions

In order to avoid repeating the same mistakes made twenty years ago during the initial rounds of telemedicine adoption, it is crucial that we develop a clearer understanding of its effects on communities, hospitals, and consumers. In summary, no standard method of net benefit estimation for telemedicine has been presented in previous research. Consider the chapter heading in a recent report to Congress: “Telemedicine Benefits Are Promising but Largely Unquantified” (U.S. Government Accounting Office 1997). Telemedicine needs to be examined in light of its effect on health care delivery and the benefits it provides to health care consumers and communities. Furthermore, given that there is both a public sentiment and a federal directive that rural residents are entitled to some basic level of health care services (however that is defined), the more relevant policy question may be: What combination of services and delivery is most efficient, and how does that change as the demographic and geographic parameters change? In this respect, information on the net benefits of telemedicine in rural settings is potentially quite valuable.

Data presently collected fall short of that needed to determine a reasonable level of public investment in rural telemedicine technologies.

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