Evaluating Telemedicine in Rural Settings: Issues and Applications

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Abstract

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 distances separates the participants—is one technology that has impacted the efficiency of delivery of rural health care services. This paper presents an overview of the telemedicine technologies, government involvement in support of telemedicine, evaluation efforts to date for these technologies, and issues that need to be addressed in designing an economic-based framework to evaluate the net benefits of telemedicine technologies to rural communities and consumers. An evaluation framework needs to be capable of quantifying the tradeoffs among access to health care services, the costs of delivery of a given level of services, and changes in the quality of the service that is being delivered via electronic communications; and how these tradeoffs shift as the level of telemedicine and the technology changes. The framework that is proposed is based on models of consumer behavior that incorporate discrete choices among quality differentiated sites.

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Over the last 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 in general and to better understand how telemedicine implementation affects the dynamics of rural health care.

This paper presents an overview of telemedicine technologies that is a prerequisite for the design of an economic framework for evaluating the impacts of telemedicine technologies. The focus is on quantifying the benefits of telemedicine in rural settings. Section I discusses recent definitions of telemedicine and the rationale for conducting economic evaluations. Section II provides a historical perspective of the use and range of telemedicine and identifies government involvement on both state and national levels. Section III reviews telemedicine evaluation efforts to date. Section IV introduces an economic evaluation framework, focusing on issues that need to be addressed in quantifying the benefits of telemedicine to rural communities and subsequent data requirements. The final section of the paper provides concluding comments.

I. Introduction and Overview

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 multi-dimensional with main considerations including how the technology will affect health care *quality*, *access* and *cost*, and the tradeoffs among them. In order to begin to make this determination, relevant costs and benefits must be correctly identified and measured. Applying economic methods to the

valuation of telemedicine systems may be a first step to understanding the effects of implementation on communities, health care facilities and consumers.

Experience with telemedicine is limited, and while its recent emergence has been met by some with enthusiasm, efforts at determining the benefits and costs are very recent. Difficulties are also encountered when classifying, identifying and obtaining 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)....." (ATSP, 1997).

The method of telemedicine evaluation proposed here includes quantifying the effects of telemedicine with the use of economic cost-benefit analysis. 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. This implies that the demand for telemedicine can be considered a derived demand, since telemedicine can be viewed as an input in the production of health care services. Alternatively, one can consider telemedicine as a technology which impacts, either positively or negatively, the specific health care service. For example, if a rural hospital has linked up with a telemedicine network for the telepathology services, then does this impact the cost of delivery of pathology services for this hospital, or should it be modeled as (hopefully) improving the quality of the pathology services that are delivered? In reality there are tradeoffs among access, costs and quality.

Within a rural setting, modeling the choice a health care consumer makes involves two stages: determining if health care will be sought, and if so, which facility or site the consumer chooses within a *rural health care system*. The second stage decision is affected by telemedicine: how does the choice of

facility vary by the presence of telemedicine. Another element in evaluating the net benefits of telemedicine includes the overall contribution that telemedicine makes to the viability of rural health care services in a given community. Thus evaluation efforts require a well thought out analytical framework which identifies methods of quantifying the direct and indirect (or use and nonuse) benefits and costs, and subsequent data needs.

Changes in rural health care

One of the observable characteristics of change in the underlying structure of rural health care is an increase in rural hospital closures. Between 1980 and 1988, 200 rural hospitals closed—the highest level of closure since record-keeping began (American Hospital Association, 1989). The health care literature commonly cites several influences as key to this situation, including changes in rural demographics, difficulty in physician retention, and the restructuring of Medicare reimbursement (Gaumer et al, 1992).

Aside from a brief period characterized by migration to non-metropolitan areas in the 1970s, many rural areas have continued to decrease in population. One result of the demographic shifts observed is a disproportionate number of elderly people in rural areas (Wright et al, 1995). An additional issue often encountered by small and isolated community hospitals is physician recruitment and retention. The difficulty in attracting and keeping physicians to 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. In 1983, the Prospective Payment System (PPS) was introduced. Under PPS, a Medicare patient is categorized according to diagnosis and a corresponding lump sum amount is paid for care, as opposed to the payment system based on the government assuming responsibility for a fraction of the hospital's cost of care which it replaced (HCFA, Waid, 1997). While Medicare policy has been significantly shifted to aid rural health care facilities,

smaller facilities commonly fail to cover costs on Medicare patients (Komisar 1991, ProPAC 1994). The Medicare program covers 95% of the nation's elderly (HCFA, Waid, 1997). As stated previously, rural hospitals serve a proportionately greater elderly and low-income population than their urban counterparts and were therefore heavily impacted by the change in payment scheme.

Health care innovation

The exit of firms from the hospital market for whatever reason has left rural citizens with a very different health care scene than in years past. Faced with these realities, new delivery methods have been developed. An example of the innovation which has come about as a result of this rapidly changing rural health care environment is the appearance of new types of rural hospitals, focusing on cooperative agreements between facilities and exhibiting a limited service philosophy.

As a result of combining two separate programs, 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 to focus 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 other program from which the CAH idea was adapted was the federally developed EACH/RPCH (Essential Access Community Hospital/Rural Primary Care Hospital) model. The primary goal of the EACH/RPCH program was to foster formal alliances between hospitals while offering critical and primary care to its patients. Elements of each model were combined for CAH implementation, including cost-based reimbursement for small, rurally located facilities limiting patient stay to less than four days.

Another method of cooperative behavior observed is the rise in the number of telemedicine networks or programs nationwide. 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 expansion of its scope and quality of services, and possibly increased cost-effectiveness in providing existing services, while the central hospital widens its referral base. Decreasing costs and higher quality equipment have made all types of telemedicine systems more commonplace than at any time previous. 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.

Rationale and Significance

Federal and state governments alike have already invested millions of support dollars meant to solve the headaches of struggling rural hospitals, and eventually bring an end to the high rate of health care inflation that has largely characterized the American "health care crisis". Telemedicine has been presented as one possibility for dealing with the challenges presented in modern day health care. Much of the telemedicine specific support has been in the form of equipment and infrastructure, as well as for 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 help determine both where and whether an additional dollar of funding for telemedicine development would be of the greatest benefit to society.

One would expect that as telemedicine proves itself to be an effective method of health care delivery, profit-oriented firms such as HMO's (health maintenance organizations) and managed care organizations will step on to the field, both indicating to the market that applications of telemedicine are an efficient use of technology in medical care, and minimizing the need for the type of research proposed here. At present, few profit-oriented health maintenance organizations have implemented their own full motion video networks. This lack of enthusiasm may signal the skepticism of the profit-oriented firms that telemedicine is worth the investment, but may also stem from a number of related issues. Since the

common use of telemedicine is still in its infancy there are multiple unresolved questions regarding licensure, malpractice coverage and patient confidentiality.

It is worth mentioning, however, that the goals of a small, frontier hospital may not be echoed in those of a more profit-centered, commonly urban based HMO structure. In a survey of small Montana hospitals, almost all had some sort of outside funding through either through a tax levy or specially directed community foundation (Capalbo et al, 1997; Shreffler, 1998). The upshot is that the value of a health care facility in a rural community with no good substitutes may be relatively greater than the presence of an additional such facility when others are readily accessible. If telemedicine can prove itself as a useful method for improving the likelihood of survival for rural hospitals, then in the interest of rural development it may be a technology worth investing in even if it would not be adopted by an individual profit-oriented firm. That is, the social benefits, measured as the sum of the private and public benefits, may outweigh the costs.

II. Historical Perspective

Although the history of telemedicine is relatively recent, elements of its past development are important in understanding current events. Also, since the term ‘telemedicine’ blankets an entire range of uses for telecommunications technology in health care, a listing and description of its many levels is included. Another important characteristic necessary for understanding telemedicine is a clear view regarding the extent of federal and state government involvement that has largely shaped the face of these programs since their inception.

Previous searches of the medical literature have found the earliest reports of medical telecommunications in the 1950's (Parsons, 1992, as cited in Crump and Pfeil, 1995) when the first successful trial of teleradiology was completed. In 1959, the University of Omaha used two way closed circuit television in transfer of patient information to medical students, and tested interactive video conference in mental health consultations until 1970. In another program, an effort was made to increase

health care of Native American Indians with use of a specially equipped van that could travel through the Papago reservation staffed by medical personnel, examine patients and use two-way microwave communication to transmit radiographic and electrocardiographic images. When funding could not be obtained, the project ended in the late 1970s (Crump and Pfeil, 1995).

It is worth noting that there are many other examples demonstrating this same pattern of initial success followed by an abrupt ending after outside funding ceased. One of the main stumbling blocks commonly cited was high transmission cost. In the early years of development, connection between distant sites often depended on satellite connection costing hundreds of dollars per hour, or a less expensive but still prohibitive option, microwave technology. In addition, it seems the experiments of the day were often technology-driven as opposed to shifting the focus of implementation to the level which would best serve health care needs in a community. 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 was known to be still in operation as of 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 have been made enabling interactive video transmission over certain types of telephone cable, significantly cutting transmission cost. Additionally, the growing presence of managed care and regional physician-hospital alliances has brought health care to a new level of competition, measured by consumers on the basis of cost, quality and access. When combined with mandated access to care and increased provider risk with regard to patient outcomes, a possible way to deal with this changing health care environment was the reintroduction of telemedicine (Perednia and Allen, 1995).

According to the Association of Telemedicine 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 some of the reporting programs excluded interpretation consults and only 97 programs of the nearly 150 telemedicine programs contacted responded to the survey. The single greatest use of telemedicine reported in the ASTP survey was for radiology. During 1996 and 1997 teleradiology and clinical drug trials accounted for nearly fifty percent of all reported consults.

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

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.

Though 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

thought to be the high fixed and variable costs in comparison to other technologies, as well as legal and regulatory ambiguities. It also 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 to 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 decision of whether and what type of telemedicine to adopt. It stands to reason that differing levels of telemedicine technologies may be appropriate for different health care situations or communities. Analysis of these decisions by health care providers and how it affects both health care systems and consumers is a vital part of understanding the implications of telemedicine implementation.

Governmental support mechanisms

Some of the first telemedicine applications were developed by NASA to monitor the health of astronauts. Since then, 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 source of federal funding for telemedicine. Mechanisms for funding have included grants for equipment and research, adjustment of Medicare reimbursement policy, and subsidized long distance rates.

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 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, so one of the highest variable costs faced by a telemedicine program include charges equivalent to constant multiple long distance telephone calls.

Since most interactive video telemedicine programs connect geographically separated facilities, a significant portion of operating cost can be long distance service. The payment arrangement between hub and spoke site for these charges varies from program to program. One scenario might find all long-distance charges assumed by the hub hospital, usually an urban center seeking to strengthen referral relationships with outlying communities. Another arrangement observed in the telemedicine market is a division of the long-distance cost between the central and remote sites.

Reimbursement is another area where federal health care policy could greatly impact the use of telemedicine. Teleradiology consults have been reimbursed by Medicare nearly since its development. The nature of traditional radiological consultation was not significantly altered by the introduction of teleradiology, since a radiologist still reads the x-ray or MRI at a location separate from the patient, as was often the case before. The only difference may be that the medium of the x-ray is digital, rather than film-based, and that the time between the MRI and the radiologist's read is potentially much shorter, especially in remote areas since physical transport of the image is eliminated.

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 provides a significant disincentive for practitioners to become involved in video consultation. Since in the United States a large portion of health care costs are financed by a government-sponsored entity, the addition of Medicare guaranteed reimbursement would change the picture significantly. In addition to the direct impact of Medicare reimbursement, there is also the probability a significant indirect effect caused by the tendency of both Medicaid and private insurers to follow the lead of Medicare (personal communication, Flaherty 6/8/98).

Test projects are underway and reimbursement on a limited basis is planned to help estimate the response of consumers to the effectively lower price of interactive video consultation.

A primary method of federal assistance for telemedicine programs has included funding for the purchase of equipment and support. Focused mainly on rural telemedicine development, a number of individual agencies have sponsored grants, including the Rural Utilities Service, and Office of Rural Health Policy. 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. Office of Rural Health Policy has sponsored numerous 3-year grants for development and expansion of rural telemedicine development. 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. The information provided in Figure 3 was abstracted from the efforts of this group. A web site, the Federal Telemedicine Gateway (http://www.tmgateway.org/), was established to convey this information.

In addition to federal monies, some states have made telemedicine development a primary health care goal. Texas policy makers have looked to the development of advanced telecommunications as one method of improving educational and health care opportunities, especially in remote areas. An annual expenditure of $150 million for 10 years has been earmarked to support telecommunications

infrastructure projects throughout the state. In some states, including Texas and California, state legislators have taken steps to facilitate more widespread physician reimbursement for telemedicine consultations.

III. Telemedicine Evaluation Efforts

A number of privately and publicly funded entities have undertaken telemedicine research, including efforts to develop methods for evaluating telemedicine systems. A number of reasons are cited for the virtual disappearance of video telemedicine following its initial use in 1970s, including small numbers of patients, high cost per patient served, unreliable equipment, and inattention to the organizational, behavioral, and financial conditions necessary for sustainability (IOM, 1996). Whether or not these factors were the actual causes of program failures, it is certainly true that increased emphasis is being placed on research focusing on telemedicine evaluation. Probably as a result of the recent arrival of managed care in the health care scene, and the accelerated level of U.S. health care inflation, increased attention has been concentrated on developing all types of health care evaluation methods. As with any type of evaluation-based studies, the goal of such research is to find out what works and why.

The first hurdle in this effort seems to be defining the term “evaluation”, since a survey of telemedicine evaluations published in the current literature yields a wide range of work. Most 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 or development of quality measurement methods.

Financial estimation can take the shape of this example, presented as cost-benefit analysis in the telemedicine literature. It is a case study of the Texas Telemedicine Project, published in Telemedicine

Journal (Preston, 1995). The paper focused on the projected use rates and cost savings of four facilities cooperating in an interactive video program as estimated by the users, then compared the estimates to actual use and savings attributable to the presence of video telemedicine. Preston reported that the total savings, number of system uses and revenue generated by avoiding transport of patients were all much lower than had been projected for the first year. A number of factors were pointed to as possible determinants of system use, such as whether practitioners are trained in the use of the technology, the level of inconvenience of scheduling and use of the system, and whether the video image offers desirable clarity and interaction necessary for the task.

While useful in its own right, the previous example is somewhat limited in scope. This traditional sort of "economic" telemedicine research focuses on the hospital's break-even point and technical issues surrounding implementation, with no consideration given to the choice of the individual seeking care, or the impact telemedicine implementation at one facility may have on the entire surrounding health care system. Another important angle to consider when measuring the benefits of telemedicine is quality of care and how it is affected. While this quality dimension is often mentioned, it is rarely addressed in financial justification articles. The limited scope of financial justification methods makes it difficult to incorporate any effect of enhanced quality into the benefits measure. Additionally, while many studies have undertaken the task of defining measurement of quality in health care, no clear method has emerged as a standard.

Another class of telemedicine research has been mainly dedicated to the clinical capabilities of the technologies. Some are from a physician's point of reference, such as accuracy of diagnoses when using telemedicine. One such study examined diagnosis using still image transfer in dermatology compared to traditional methods, (Perednia, 1994). A further step considers patient outcomes when telemedicine technologies are implemented into the regimen of care. An example of this type of

evaluation is a study comparing the clinical efficacy of telepsychiatry to the psychiatric care provided in person (Folsom, 1995).

Two large-scale telemedicine evaluation research projects are currently underway. The Center for Health Policy Research, in cooperation with the Telemedicine Research Center, is heading up one of these. Objectives of this Health Care Financing Administration (HCFA) financed research include development of policy for Medicare concerning utilization review and payment methods for telemedicine 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 then comparing this information to results of a control group, the researchers hoped to gain a better understanding of both cost-effectiveness and clinical outcomes when telemedicine is used in treatment. This can be used as a proxy for a measure of quality. Another part of the project was designed to compare the effects and effectiveness of different types of telemedicine technologies.

Another 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.

There is no shortage of information regarding telemedicine evaluation in one form or another (see IOM, 1996; TRC, 1998; Drummond, 1987). However, some important considerations have been left untouched in studies to date. The following are two observations regarding the way telemedicine is viewed in the current evaluation literature. First, it is treated as a stand-alone procedure and analyzed independent from the health care system. Additionally, the impacts of telemedicine have been limited primarily to analyzing its clinical effects on patients and the hub facility. A more complete evaluation of a telemedicine program would include not only the short term benefits to the originating hospital, but also account for the value of strengthened referral relationships with outlying facilities. Additional

benefits of telemedicine could also be accounted for far outside the urban hospital, to rural patients, spoke hospitals, and communities. In summary, telemedicine needs to be assessed as an integral part of the delivery of health care services to rural communities.

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. Additional benefits include the value to a rural hospital of the potential for increased scope of care and connection with a larger facility, and the benefits to a community of maintaining a given level of locally available health care services. Furthermore, in measuring the benefits of increased use of telemedicine at a given location the substitution of medical care away from sites without telemedicine needs to be included.

According to its supporters, when developed and implemented thoughtfully, telemedicine systems may have the potential to simultaneously address several problems currently common in health care (especially in rural areas), including access to care, cost containment, and quality assurance. (Bashshur, 1995). Access can be improved by linking providers in remote areas with others who can offer professional support, such as specialists in metropolitan centers or peers in rural areas. This 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 (Capalbo et. al., 1997; Shreffler et. al., 1998). The main goal of optimal patient care is to promote the use of appropriate services, by appropriate providers, at the appropriate site while discouraging inappropriate use. Cost containment is further promoted by the substitution of lower-cost for higher-cost providers and facilities. Ideally, improved quality will be achieved by ready availability of consultations and referrals. In a perfect world, these would be benefits of telemedicine implementation, but they are largely based on assumptions that have not yet been verified

in a field setting. It is still unclear whether video telemedicine promotes use of lower-cost facilities and personnel at all, or that it provides opportunities for increased quality of care (Bashshur, 1995).

IV. Economic Framework for Evaluating Telemedicine Technologies

Benefit-Cost Analysis

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. An ex ante BCA of telemedicine technologies requires a prediction of the direct and indirect effects, expressions of the effects in terms of common units, and a determination of the net impact on social welfare. This requires a criterion for determining what qualifies as an increase in welfare and a means for aggregating the impacts that may occur at different points in time. The standard procedure is to use the present discounted value of net benefits as the criterion for evaluating changes in social welfare.

The issue of aggregation and to whom the benefits and costs accrue comes into play because the benefits accrue primarily to the patient in the form of more readily available specialty consultations and reduced travel time. On the other hand, these consumers are not currently responsible for additional costs that may result from telemedicine use. These 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, while 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 forego involvement in telemedicine altogether. Any policy or evaluation of telemedicine must take into consideration the effects of disparate distribution of costs and benefits between different parties including patients, physicians and taxpayers.

In telemedicine, the stream of benefits may reach far into the future while a large portion of the costs are borne at the beginning of the project. Due to the specialized nature of the equipment,

telemedicine systems can have sizeable fixed costs associated with their implementation. The choice of a reasonable discount rate is crucial to obtaining useful results in a benefit cost analysis.

As evidenced by the discussions in Section II, the full effects of telemedicine implementation are as yet unknown. One of the most crucial factors for designing a cost-benefit analysis of telemedicine is the realization that a great amount of 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? And if so, how sensitive are these decisions to distance, types of service needed, etc. Factors that may influence the measure of benefits to society include whether telemedicine enhances quality of care or if it gives rural hospitals a greater likelihood for survival. While complex, this challenge is not unique to the evaluation of telemedicine and has also been addressed in other settings including evaluation of new and emerging agricultural technologies and in evaluating the net returns from publicly-funded research. In *Science Under Scarcity,* Alston, Norton and Pardey (1995) provide a discussion of methods for quantifying the net benefits of research, different ways of classifying and estimating economic surplus, and methods to prioritize research funding.

Brief Literature Review

Most of the economic research on quantifying the demand for health care services has been centered around health care in an urban setting and/or has focused on a given specialty service. A more complete review of this literature is found in Heggem (1998). An exception is the study by Gertler and Van der Gaag (1990) which analyzed willingness to pay for health care in rural communities in Peru and Cote d'Ivoire using an expenditure function approach. The welfare impacts of a change in the implicit price of health care is measured as the change in expenditures necessary to achieve a given level of utility after the price change has occurred. In the Gertler and Van der Gaag study price is a combination of money price for the visit as well as estimated travel costs. This difference in income is known as the

compensating variation: the maximum amount a household would be willing to pay for a decrease in the price of a visit due to increase in access or shortened distance to available care.

Gertler and Van der Gaag make note of several limitations in applying their model to estimate the demand for health care. In the case of medical services run by governments, there may be little or no variation in monetary price within a country. Even if a positive price is assessed for medical visits, it may be uniform across all sites. This same situation may be faced within a telemedicine system, where even if a positive price is paid for use of the system, usually there is no variation among sites.

The Rand Corporation's health insurance experiment (Manning et. al., 1987) focused on isolating the determinants of how much medical care individuals choose to consume, given that they choose to seek care, as well as whether they choose to seek care at all. The authors found that price was a major factor in determining the amount of medical care consumed.

McNamara (1996) utilized a discrete choice framework to model the decision of where to seek medical care for hospitalization services. In the vector specifying facility attributes and personal attributes, variables such as local facility bedsize, number of physicians, age, race and distance to alternative care were included. Cross elasticities were presented showing the change of probability of choosing the nearest hospital if there was a change in distance to or bedsize of an alternative facility, as well as family income. Elasticities reported include .082 for distance to the nearest rural hospital, and .208 for distance to the nearest urban hospital.

An alternative means of quantifying the benefits of telemedicine technologies is input-output (I/O) analysis. I/O analysis measures the economic effects of the health care sector on a local economy. It is a programming approach to measurement of economic benefits. If telemedicine provides for a more viable health care sector then there are the multiplier impacts on the local economy that are attributable to telemedicine. Cordes, 1994 and Doeksen et al, 1998 are two examples of research that utilized I/O to quantify the impacts of health sector on the local economy. Utilizing data from nine Oklahoma counties,

and the UDSA IMPLAN program, Doeksen et al (1998) estimated employment and income multipliers ranging from 1.30 to 1.87. The challenge of using multiplier analysis to value telemedicine is to isolate the proportion of the impacts that can be attributed primarily to telemedicine.

Modeling the Impacts of Telemedicine

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:

(1) 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;

(2) 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 relate to the specific service being offered; and

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

An evaluation framework needs to be able to address each of these types of impacts—its magnitude and value—and to quantify the tradeoffs among cost, access and quality and how these tradeoffs shift as the level of telemedicine and the technology changes. These tradeoff relationships are determined by the choices that consumers and communities make with regards to utilization of alternative health care options. Thus the evaluation framework and the welfare measurement should be based on models of behavior of consumers which are capable of quantifying how behavior changes as the options and costs of these options change.

Each of the three types of impacts can be illustrated using simple economic diagrams. Does telemedicine shift the marginal cost curve of providing rural health care services, changing the price for a given service and thereby moving along a given demand curve for rural health care services? Or does telemedicine shift the demand curve for rural health care services because quality has changed? If the former is true, the benefits of telemedicine are measured as the change in consumer surplus associated with the price change as depicted in Figure 4. If telemedicine enhances the quality of a given service, then this would be reflected in an outward shift of the demand curve for rural health care services; and the benefits would be measured as the increase in consumer surplus is a result of consumers increased willingness to pay for health care of higher quality (Figure 5). This model is similar to that used by Unnevehr (1986) to quantify the benefits to consumers of a quality improvement in rice.

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 to 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.

The travel cost model, the discrete choice or random utility models and the hedonic travel cost model have all been used to model the demand for recreational services and to a limited degree to estimate the value of quality improvements to a recreational site. These three models have been used to quantify the use values associated with a specific recreational site or with a given recreational system composed of numerous sites.

In the resource economics literature, values that are independent of people's present use of the resource have been termed "nonuse" values. While these nonuse values arise for a number of reasons, the

one most relevant for health care modeling is associated with a desire to preserve the options for future use. While the concept of nonuse values are acceptable, how to quantify the magnitude of these values is less clear (see Freeman, 1992 for an extended discussion). One issue that needs to be resolved in the health care modeling is the degree to which the methods proposed to model the demand for rural health care reflects both use and nonuse values, i.e., total value, and how large is the magnitude of the nonuse values. Preliminary discussions with rural community members in Montana suggest that many communities subsidize the provision of local health care for both its use and nonuse ("having it there in case we need it") values. This implies that a methodological framework for valuing rural health care should address the nonuse or option value component as well as the use value component.

The travel cost model (TCM) is one of the most well known models used in the study of recreational demand. It combines information regarding rates of visitation with the full cost to the participant of that visit to develop a demand curve. Its use is predominant in cases where there is not sufficient variation in price among consumers (if a price for use of the site exists at all) to otherwise obtain a meaningful demand curve.

Observations on the number of visits to a health care site, combined with information on occupations, travel time etc., provide a basis for estimating the demand for a specific health care site or facility. Extensions of the travel cost model include accommodating multiple sites. Using a travel cost framework, the benefits to a consumer of telemedicine can be approximated as the savings as reflected in reduced travel time and lost wages. If the consumer previously had to travel to a more distant site to obtain the desired services, the benefits could be calculated as the gains in consumer surplus associated with a lower "full price" of a visit.

As with other demand modeling tools, the travel cost method has its limitations. Difficulties that may be encountered when using TCM include estimation of the opportunity cost of time and how time spent at the site is treated, multiple purpose trips, possible endogeneity of the travel cost variable, and

truncated data. Since the only survey subjects under this design are users, estimation difficulty may arise (see Boardman, et. al., 1996 and Freeman, 1992).

In Montana, it has been observed that the users of telemedicine do not face a varying scale of payment for consultations (Armstrong, personal communication, June 1997). Under the single site travel cost model, the value of telemedicine technology at a site can be estimated using the travel cost averted by consumers when telemedicine is implemented. However, if the relevant research questions involve the changes in the values of many telemedicine sites, i.e., if we implement telemedicine in Eastern Montana, then the interaction and substitution effects among the alternative sites must be modeled explicitly, using some form of a multi-site model. However, as noted by Freeman (1992) and others, it is difficult for multi-site travel cost models to take into account differences in site characteristics. The effects of quality on visitation rate can be difficult to separate from travel cost.

The discrete choice or random utility model (RUM), with its emphasis on explaining the choice among sites as a function of the quality of the services offered at the site, is better suited to quantifying the variations in site quality on the demand for health care services at that site. Discrete choice modeling differs from other types of analysis in that the individual consumer does not necessarily optimize over a range of continuously variable consumption options. Instead of predicting how often the individual will seek medical care at a given price, the discrete choice model would predict where care would most likely be sought, given the attributes of each site. The emphasis is on the tradeoff among the services offered at quality differentiated sites. A complete description of the discrete choice model to quantify the demand for rural health care is forthcoming in Capalbo (1999).

A third model that is used in the recreational demand modeling is the hedonic travel cost model (Brown and Mendelsohn, 1984). This model attempts to estimate shadow values for the characteristics of the site by estimating the individuals' demand for the characteristics. In essence, the hedonic travel cost model uses information on the additional costs of accessing a site with higher quality characteristics to

estimate the demand for quality. Quality is treated explicitly as a decision variable. To the extent that an array of health care sites exist where increasing quality can be purchased at higher travel costs and the individual is free to choose among the sites, then this model can be used to estimate the demand function for health care quality.

Applying the hedonic travel cost model to valuing rural telemedicine requires that we have a good measure of how telemedicine relates to quality. Critics of the hedonic travel cost model indicate that the approach does not predict how consumer's behavior with respect to choice of a site would change as the quality of the site changes (see Bockstael et al 1987). Given this inherent flaw in the hedonic travel cost framework, it is probably less attractive for quantifying the benefits of telemedicine.

Data Requirements and Limitations

To our knowledge, the data needed to estimate a behavioral-based model of rural health care demand do not exist. Ideally, one would want data from a random household survey of both consumers and nonconsumers of health care services in a given rural region. For each consumer, a complete pattern of health care choices is needed including the demographics and income levels. In addition, each health care site in the region needs to have objective measures of quality including the degree of telemedicine services that are offered. The survey instrument to collect such data could be patterned after the survey used in the Rand Study on hospitalization demand.

Our review of the existing information on telemedicine usage, indicates that the data that are collected provide an overview of the number and types of consults, 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. What is missing 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 their demographic and health care history. For example, information provided by the Eastern Montana Telemedicine Network allows one to examine trends in use rates over time, and zip

codes for the users, length of consult, number of personnel involved, and a limited set of information on the occupation of the consumer. Using this information, in conjunction with simplifying assumptions regarding single-purpose trips and lack of available substitutes, one can provide an upper estimate on the benefits of each telemedicine consult, measured as averted costs.

While this information 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 and how the tradeoffs among quality, cost, and access shift in response to telemedicine investments.

V. Conclusions

In summary, no standard method of net benefit estimation for telemedicine has been presented in previous research. Consider the chapter heading in a recent GAO report to Congress: "Telemedicine Benefits Are Promising but Largely Unquantified" (GAO, 1997). Telemedicine needs to be examined as part of the larger picture of health care delivery, rather than on its own. Furthermore, the more relevant policy question to ask may be: 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), what combination of services and delivery is most efficient, and how does that change as the demographics and geographic parameters change. In this respect information on the net benefits of telemedicine in rural settings is needed information.

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. Whether telemedicine ultimately makes good economic sense for rural communities may be influenced by the degree of "cost sharing" of health care applications with other telecommunications services. While such an analysis is beyond the scope of this research, the evaluation

of telemedicine services as part of a joint product with other Telecommunications Services is useful to Rural Development Policy.

One of the most promising frameworks to quantify the use values or benefits of telemedicine services to rural consumers and communities is a discrete choice framework. 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 and different quality; and the value of telemedicine services at a given site depending 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 which models the nature of the health care decision and the substitutability or tradeoff 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 system. Using the estimated behavioral relations from a discrete choice model in a simulation model will provide some information on the tradeoffs among cost, quality, and access for rural communities.

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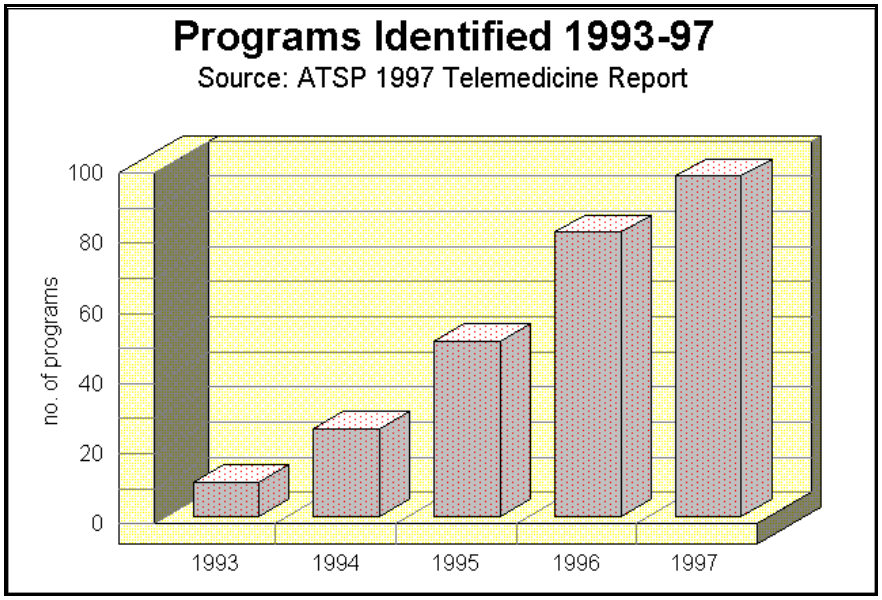

Figure 1
Telemedicine Programs reporting activity in the U.S.

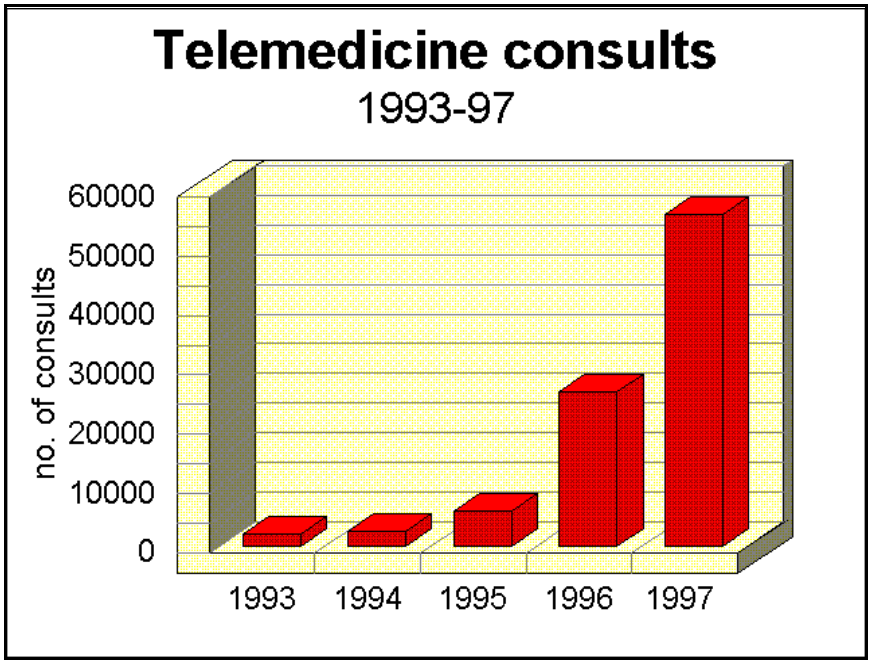

Figure 2

Source: 1997 ATSP Telemedicine Report and Telemedicine Today Magazine Program Reviews 1994, 1995,1996
(1997 figure projected from first quarter data)

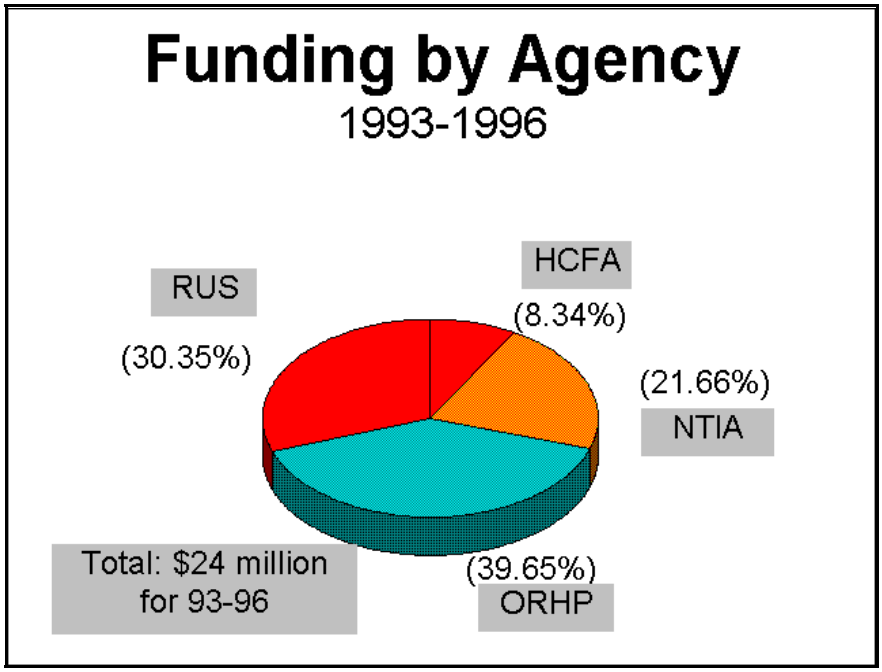

Figure 3
Source: The Federal Telemedicine Gateway (1998)

RUS: Rural Utilities Service
HCFA: Health Care Financing Administration
NTIA: National Telecommunications and Information Administration
ORHP: Office of Rural Health Policy

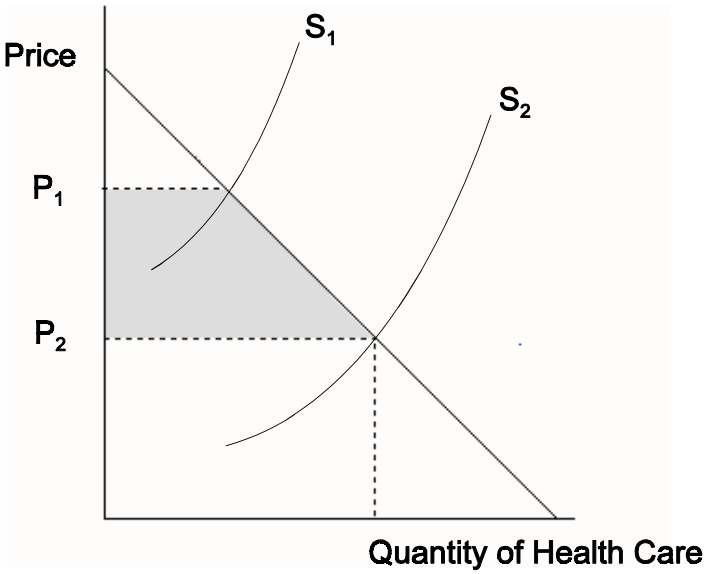

Figure 4
Change in Consumer Surplus Resulting
from a Decrease in Marginal Cost of
Providing Health Care Services

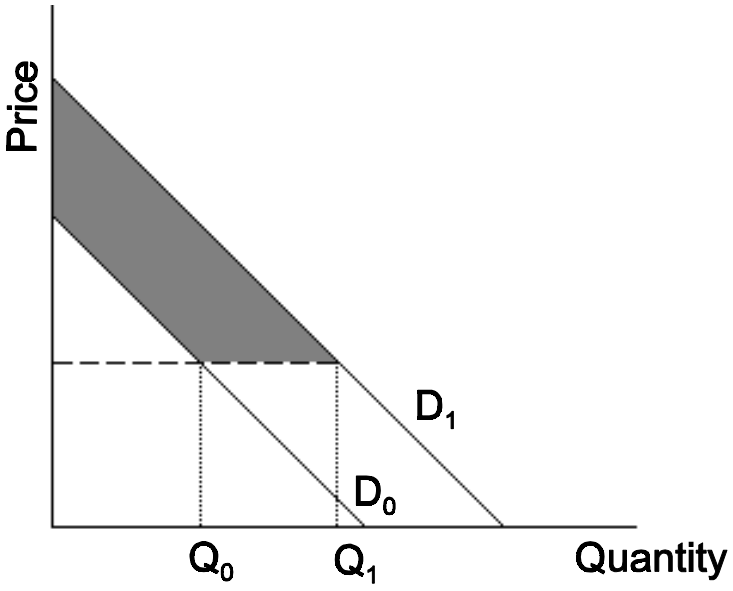

Figure 5
Change in Consumer Surplus as a Result
of Increase in Health Care Quality