Evaluating Telemedicine in a Changing Technological Era

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Since the early 1960s, there have been numerous attempts to apply telecommunications technology to enhance and provide healthcare over dispersed geographic locations. This method or process of healthcare delivery is called telemedicine, or “medicine at a distance.” It enables electronic transmission of patient information between healthcare providers via a variety of modalities (phone, fax, interactive video, Web-based multimedia e-mail, still image video, and so on). The patient receives healthcare without being physically referred to the consulting healthcare provider.

Early clinical experience with telemedicine focused primarily on expensive demonstration projects, many using interactive video telecommunications technology. For the most part, these systems have failed once extramural funding was withdrawn. The challenge for today is the design of new telemedicine solutions that are simple, transparent to the healthcare delivery process, open and flexible to incorporate changing technologies, needs-based or modality oriented (for example, store-and-forward multimedia e-mail for routine consults, real-time video for face-to-face psychiatry applications, and so on), self-sustaining, and cost effective. Simultaneously, we must investigate through rigorous scientific methodology how well telemedicine systems are fulfilling their intended purpose in a rapidly changing healthcare and technology world.

Over the years, most clinical applications of telemedicine have not been subject to rigorous comparative studies to assess their effects on the cost, quality, and access to healthcare or patient and provider acceptance. Little information of value exists as to how telemedicine impacted healthcare delivery in the past. However, the lack of historical data may not be an important concern today. Although some studies have employed sound scientific methods and analyses and the research designs may be quite good and applicable today, the studies were done in the context of old technology and results may not be

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transferable to the modern telemedicine scenario. Therefore, we are beginning anew to build a sound evaluation research base for telemedicine within the context of more advanced technologies.

The telemedicine of the 1990s and new millennium, with its enhanced technological capabilities (such as compact, user-friendly personal computers, multimedia e-mail that can send graphics, images, video clips, and sound bytes; high-speed Internet/World Wide Web; sophisticated electronics, hardware, and software; and greater affordability) lends itself to a new set of research questions, satisfaction criteria, and evaluation outcomes. We can glean as much as possible from past research methodologies and lessons learned and begin a serious commitment to a continuous reappraisal of how well new technologies are serving our needs.

**Historical Perspective: Obstacles in Telemedicine Evaluation**

Evaluation is a form of applied research that seeks to build knowledge and provide information useful to decision makers. Telemedicine evaluation investigates the impact of telecommunications technologies on healthcare delivery and processes and provides evidence of their effectiveness. The goal is to provide information on the comparative benefits, risks, and costs of telemedicine applications.

Historical telemedicine evaluation literature reveals a modest research base, limited documentation of methods, and research designs changing during implementation. Literature reviews include extensive reviews conducted by the Center for Health Policy Research to determine whether the literature supported the use of telemedicine as a safe, medically effective set of procedures.\(^1\), \(^2\), \(^3\), \(^4\), \(^5\) There are few peer-reviewed studies, a limited amount of work in progress, and a mix of research approaches with no replications or cross-validating studies.\(^5\) A review by Sanders and Bashshur yielded similar findings, concluding that much of the appeal of telemedicine remains intuitive and is based on fragmentary rather than systematic empirical research.\(^6\)

History indicates that telemedicine evaluation (if considered at all) is too often an afterthought considered after the more important issues of putting a program together are in place. Other reasons for questionable study quality, evaluation studies not being completed, or studies not initiated include the following: \(^7\)

1. Intuition or assumptions may exist that “better” technology can always improve a situation or solve problems. (Therefore, there is no need to evaluate it.)
2. Deliberate and rigorous evaluation can be difficult to apply in parallel with the great enthusiasm generated with developing projects that incorporate interesting and innovative technology.
3. Disciplined and systematic evaluation requires time to plan, fund, and implement—expensive commodities that are often obtained with difficulty and are difficult to sustain throughout a study period. A study may never get started or stop midway through its course.

4. If the research questions and methods are not well-defined, a substantial amount of uncertainty will surround the effort, the results will be of poor quality, or the study will be abandoned.

5. Regardless of the amount of planning done, technological events occur (glitches, hardware problems, technology becomes obsolete, and so on) that can have major impact on the research process, outcomes, or applicability.

The above list of obstacles to telemedicine evaluation is not extensive nor all-inclusive. However, it does illustrate that strong forces are ever-present and can prevent such studies from occurring or being taken to completion. History has taught us that we need to make a conscious and deliberate decision to implement evaluation plans, set realistic goals for their completion, and secure appropriate resources to carry them out.

Learning from the Past: Strategies for Telemedicine Evaluation

Certain concepts and steps are common to the planning of successful evaluations. The following list reflects generic evaluation strategies distilled from decades of work in many fields. These may be viewed as modern guidelines for telemedicine evaluation research.

1. Assess the probable feasibility and chance of successful execution of an evaluation, including availability of funding, cooperation from participants, available resources, time required, and so on.

2. Establish evaluation objectives and research questions.

3. Develop an evaluation strategy that includes a feasible and scientifically sound research design and analysis plan.

4. Identify the variables to be evaluated, particular intervention, and alternatives to which it will be compared and the measurable outcomes of interest.

5. Specify expected relationships between interventions and outcomes and the other factors that might effect them. Include techniques to assess to what extent conclusions may change if assumptions or values of key variables change (sensitivity analysis).

6. Commit to an explicit documentation and reporting process so that others can review how results were obtained and analyzed, and so they are able to repeat or validate the study.

Telemedicine evaluation has been taken quite seriously at the federal level and reflects an organized and serious approach toward metrics and the pursuit
of data. In 1995, after Vice President Al Gore asked the Department of Health and Human Services (DHHS) to take a greater leadership role in developing cost-effective health applications for the National Information Infrastructure (NII), the Commerce Department joined forces with DHHS to form the Joint Working Group on Telemedicine (JWGT). The JWGT is charged with assessing the role of the federal government in telemedicine and coordinating telemedicine activities across federal cabinet agencies. Part of that task involves developing specific actions to overcome barriers to the effective use of telemedicine technologies. The JWGT has attempted to develop a broad evaluation framework for telemedicine. The goal was a document and discussion process that would strengthen evaluation designs and promote comparable evaluations.

The working group identified different types of evaluations related to different strategies:

1. Early “proof of concept” studies that tested the basic feasibility and logic of the intervention (for example, demonstration projects)
2. Assessment studies to further demonstrate operational feasibility and perceived value in the field
3. Clinical trials that more rigorously collect and analyze data on the intervention’s effect (the greatest telemedicine research deficit to date occurs in this area)

Given the complexity in which telemedicine implementation is embedded, JWGT has also identified critical questions to measure the impact of telemedicine within a healthcare delivery system in six general domains:

1. Are acceptable clinical outcomes associated with the use of telemedicine?
2. Is the system technically acceptable?
3. How well is the system integrated into the overall health system?
4. What are the costs and benefits in day-to-day operations? Is the system affordable?
5. Will patients and providers accept and value telemedicine care?
6. Will the use of telemedicine improve access to healthcare?

Overall, telemedicine is similar to other technologies for which evidence of effectiveness is required. Telemedicine, however, has some unique characteristics. For example, telemedicine is not a single technology or a set of related technologies; it is a complex collection of clinical practices, technologies, organizational arrangements, and human factors and acceptance considerations. Widespread adoption of telemedicine applications depends on a multifaceted, widely distributed technical and human infrastructure that is only partly in place today and is being rapidly affected by changes in healthcare information and communications systems.
The rapid rate of change and other uncertainties associated with telemedicine applications also argue for sensitivity analyses to explore how conclusions may change if values of key variables or assumptions change. It also argues for thinking broadly about potential benefits and costs, carefully documenting how the technical infrastructure and the clinical processes of care were intended to operate and tracking what actually occurs. This step is crucial if evaluators who show negative results are to determine whether the hypothesis linking independent and dependent variables was untenable or whether the hypothesis was not actually tested because the application was not implemented as intended. By tracking what actually occurs, evaluators also may achieve a fuller understanding of critical success factors or the factors that, if changed, might improve results.

**A Military Example of Telemedicine Evaluation**

A number of government and private organizations have made serious efforts to support improved telemedicine evaluation frameworks and strategies. These organizations include the Health Care Financing Administration, National Library of Medicine, the Agency for Health Care Policy and Research, Office of Rural Health Policy (in the U.S. Department of Health and Human Services), the National Institute of Standards and Technology, the National Telecommunications and Information Administration, the Department of Veterans Affairs, and the Department of Defense. However, many federal agencies are facing budget cuts. As a result, the bulk of telemedicine evaluation research may fall on the military and Veterans Affairs's health systems due to internal economic incentives to evaluate the utility of telemedicine.

As a mostly self-contained system, the military offers a number of advantages for evaluators compared to the civilian sector. These include

1. A large, defined population
2. An integrated healthcare delivery and financing system
3. Integrated medical records and better access to follow up data on patients
4. Salaried, full-time personnel to conduct research
5. A command structure that can promote cooperation internally and across diverse sites
6. Freedom from state regulation
7. Multiple sites for comparing care alternatives and providing data
8. Well-developed research and development resources
9. The ability to leverage and stimulate development of better vendor data on the effectiveness and costs of relevant hardware and software (because the military is a major purchaser of information and communications technologies)
In 1995, the U.S. Army convened a two-week session led by Tripler Army Medical Center (TAMC), Hawaii, that focused on developing clinical indicators for evaluation. Tripler is the central point of a Pacific-wide developing telemedicine system that is to support military operations and involve other governmental and private organizations in improving access to care in remote parts of the region.

The clinical indicators are now being applied to a federally funded research project called AKAMAI. (Akamai is a Hawaiian word meaning “clever” or “smart.”) For this project, TAMC is playing a major role in pioneering telemedicine implementation and evaluation in the Pacific. This program intends to augment healthcare delivery to the Department of Defense (DoD) and other beneficiaries in the Pacific Basin using advanced telecommunications technology. The goal is to allow more patients to receive definitive treatment at their local healthcare facility and, thus, avoid the requirement for aeromedical evacuation. The major objective of the evaluation piece of the program is to provide healthcare policy makers with scientific information to assist them in the decision to deploy telemedicine systems within the DoD.24 The evaluation study consists of four domains that address the research aim to investigate if and how telemedicine consultation between medical treatment facilities

1. Impacts the clinical outcome of patients compared to usual care
2. Affects patient and provider satisfaction compared to usual care
3. Reduces cost in relation to benefits compared to usual care
4. Affects organizational structure and learning

The general evaluation project protocol employs a randomized design to compare patient and process outcomes of two methods of consultation (telemedicine and usual care) from a primary care outpatient clinic (located at Schofield Barracks, Hawaii) to a tertiary care medical center (Tripler Army Medical Center). The sample population is active duty, retired military, and their dependents requiring consultation from a primary care to a tertiary care facility. The study has implemented a research data base that is able to house patient information pulled from various DoD patient information sources, as well as local healthcare systems, and store this information for later data analysis. This will allow for data table assembly and a patient trajectory to be generated where the investigators can retrospectively follow the patient through the healthcare system and assess the impact of telemedicine on patient outcomes, cost, and benefit. In its general scope and execution, the study closely follows the guidelines set forth by the JWGT. Plans call for completion in the year 2000.25 In addition to answering specific research questions, this effort will also establish a methodology for evaluating additional military sites using telemedicine systems, and it will make available satisfaction survey tools applicable to DoD and civilian use.26
Past Evaluation Studies: What Have We Learned So Far?

Although studies evaluating telemedicine have been conducted over a thirty-year history, what do these studies really tell us, and how reliable are their findings? This depends on the quality and caliber of the methodology and the data and conclusions obtained. A historical analysis of this type is actually an important evaluation effort in itself.

To sift out a subset of studies meeting eligibility criteria for inclusion in such an analysis, Balas and others27 collected published randomized controlled trials (1966–1997) evaluating distance medicine technologies to evaluate the quality of the randomized controlled trials using previously developed methodologic evaluation tool, categorize and describe the various distance medicine interventions evaluated, and summarize the available evidence on the ability of distance medicine to improve care in specific clinical areas. Three eligibility criteria were applied: prospective, contemporaneously controlled clinical trial with random assignment of the intervention; electronic distance technology application in the intervention group and no similar intervention in the control group; and measurement of the intervention effect on process or outcome of care. Distance technology applications were described in six categories: computerized communication, telephone follow-up and counseling, telephone reminders, interactive telephone systems, after-hours telephone access, and telephone screening. Of eighty eligible clinical trials, sixty-one (76 percent) analyzed provider-initiated communication with patients and fifty (63 percent) reported positive outcomes, improved performance, or significant benefits, including studies of computerized communication (seven of seven), telephone follow-up and counseling (twenty of thirty-seven), telephone reminders (fourteen of twenty-three), interactive telephone systems (five of six), telephone access (three of four), and telephone screening (one of three). Significantly improved outcomes were demonstrated in studies of preventive care, management of osteoarthritis, cardiac rehabilitation, and diabetes care. The authors concluded that distance medicine technology enables greater continuity of care by improving access and supporting the coordination of activities by a clinician. Although the findings tend to validate many of our intuitive thoughts, as technologies advance and improve, we must see if the basic conclusions continue to be expressed. We must also continuously update our understanding with new findings.

Conclusion

There is concern about the wisdom of rapid deployment of telemedicine systems before we have established technical standards, effective clinical protocols, and organizational structures for the proper implementation of telemedicine. However, even more important, we have yet to understand and fully
demonstrate how telemedicine can effectively deal with the lingering problems of cost, quality, and access to healthcare. We know that information technology will continue to expand and outdistance our abilities to develop effective organizational structures and methods for its optimal utilization. As long as we are aware of this, we can make a conscious effort to assess the benefits of the technology and, as a result, tailor it to more adequately fit our human needs. This begs an effort to build in or attach evaluation components routinely to newly deployed telemedicine systems.

Much remains to be done to build evaluation into telemedicine programs and to see more well-designed and executed studies of specific applications. More rigorous evaluations of telemedicine applications will produce the positive findings that will encourage wider adoption of these applications. In other cases, the results may be disappointing, yet they may also stimulate further technical innovation and more attention to user needs and circumstances; thus, even negative results can be viewed as important opportunities. The task for evaluators is not to justify telemedicine as such but to provide the credible and relevant information base needed to enable immediate decisions and plans for the future.

References


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