

Economic Analysis of Telemedicine and the Teledermatology Paradigm

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Abstract

Economic considerations are an important component in the planning and execution of a telemedicine program. The goal of this review is to familiarize readers with economic concepts relevant to the analysis of telemedicine programs. Economic perspectives, cost attribution, types of economic analysis, and commonly encountered problems will be discussed as they pertain to telemedicine. Societal perspectives, healthcare system perspectives, patient perspectives, fixed versus variable costs, labor costs, and distinctions between cost-effectiveness analyses and other types of economic analysis also will be examined. Examples from the teledermatology literature will be used as a paradigm to illustrate how these concepts are integrated into existing analyses of teledermatology systems. Teledermatology shows promise as a cost-saving healthcare delivery system with outcomes comparable to or better than those of conventional care processes. The literature also points out the importance of economic perspectives in the findings and interpretation of an analysis.

Key words: *business administration/economics, teledermatology, dermatology, telemedicine*

Introduction

Economic considerations are vital to the planning of a telemedicine program and when deciding whether or not to adopt such a program. Telemedicine interventions provide similar or improved clinical outcomes compared to conventional care.¹⁻⁴ However, economic advantages in the face of comparable or superior clinical outcomes, or favorable cost-

effectiveness ratios when clinical superiority is demonstrated despite higher total costs, may serve as compelling reasons to consider the adoption of telemedicine technology.

The goal of this review is to familiarize readers with concepts and issues that are important when performing or reviewing economic analyses of telemedicine programs. Included are basic concepts relevant to any economic analysis. These concepts will be illustrated using examples from the teledermatology literature.

Economic Perspective

The economic perspective of an analysis is an essential consideration. Analyses can take more than one economic perspective, but the Panel on Cost Effectiveness in Health and Medicine recommends that the societal perspective be considered always.⁵ This means that all costs and outcomes that affect the society at-large, that is, costs borne by the healthcare system, patient, private enterprise, government, and any other affected entity, are considered.

The perspectives of patients and those of the healthcare system are other examples of economic perspectives. If a particular healthcare system is deliberating over telemedicine implementation, then the costs and outcomes incurred directly by the system would be of most interest to its decision-makers. Those costs borne only by the patients (copays, deductibles, travel costs, and loss of productivity costs) are not directly attributable to the healthcare system. However, if one were interested in the patient perspective, these same features (copayments, deductibles, etc.) would become relevant. The type of economic perspective chosen should always be explicitly stated and accurately assessed and attributed.

Cost Considerations

Telemedicine interventions require a communication infrastructure, which comes at a large cost in some cases. In general, telemedicine requires hardware, software, and other communication commodities (e.g., communication lines or "landlines," wireless networks, etc.) to function. However, most often the communication

infrastructure exists prior to the development of the telemedicine intervention and serves myriad other uses. In such cases, the cost incurred by the communication technology can be considered a type or variation of a sunk cost, implying that it is not directly attributable to the telemedicine intervention as the costs have already been incurred. Without telemedicine, the infrastructure would remain intact and be used for the general medical enterprise. The electronic medical record used by the U.S. Department of Veterans Affairs is a good example. While not developed for telemedicine, the record allows clinician-to-clinician communication and provides a mechanism to perform store-and-forward telemedicine via its consult package and image storage capability. The cost of developing, updating, and maintaining the electronic medical record would not be attributed directly to telemedicine because (1) the system was developed for clinical care and record keeping and exists regardless of telemedicine applications and (2) any use of the electronic record by telemedicine would be an incrementally small portion of its total use and adds no significant additional cost to the system. Telemedicine, in this case, takes advantage of a preexisting network. Of course, if an infrastructure was developed specifically for telemedicine or if telemedicine used a significant portion of a system that incurs opportunity costs, then one should not consider those costs as sunk. An example is the use of a high-bandwidth line with limited access. High bandwidth time often must be reserved for telemedicine, which incurs opportunity costs. Here the time used for telemedicine precludes that for other uses such as continuing education teleconferences.

Hardware or equipment that cannot be considered a sunk cost should be subject to cost accounting. Generally, prevailing market prices with depreciation over a useful lifetime should be used. Computers have a prevailing market price, albeit constantly changing, and generally have a useful lifetime of 3–4 years. Therefore, a computer's value decreases to nil over a 3- to 4-year period; if straight-line depreciation is used this would occur in equal increments to the end-value point.

Labor costs are important because, as is often the case, they are usually the most material driver of economic outcomes. Telemedicine interventions that require dedicated personnel should include the cost of providing fringe benefits in the total salary, which is often 20–30% of the base salary. For part-time practitioners of telemedicine, techniques such as time studies (observation or self-recording of actual time spent on telemedicine activities compared to nontelemedicine tasks) may be more appropriate. This typically yields a labor cost per unit time that can then be translated into the time frame of interest for the analysis (e.g., annualized labor costs).

Costs can be dichotomized into fixed and variable costs. Fixed costs are those that do not vary by patient volume. This would include equipment costs that cannot be considered sunk costs. For example, regardless of whether 1 or 1,000 telemedicine consults per month are performed, a telemedicine-dedicated laptop computer might be required to perform the consults. Consult volume does not affect the fixed cost of purchasing the laptop. Variable costs, however, are influenced by patient volume. Labor costs are perhaps the most obvious variable cost. A greater number of consults would require a larger portion of a clinician's or a technician's time to manage and answer the consults. If the personnel are not salaried and solely dedicated to telemedicine, the variable volume would concurrently result in greater labor costs being attributed to telemedicine. Another example of a variable cost is travel cost or travel cost reimbursements. Telemedicine often precludes the need for clinic visits, thereby reducing travel requirements and lowering travel costs in a volume-dependent fashion.

Types of Economic Analysis

The type of economic analysis in published reports is frequently misattributed. The term “cost-effectiveness” is commonly used in a generic sense for any economic analysis. Cost-effectiveness is a specific term implying that both relative costs and relative effectiveness of two or more competing strategies have been assessed. The measure of effectiveness can be any relevant or accepted feature, and can be a terminal event (e.g., lives saved) or an intermediate outcome (e.g., clinic visits averted). Often, quality-adjusted life years (QALYs) are used, which take into account how a particular intervention impacts both the quantity of life (mortality) and the quality of life (morbidity).⁵ Measures of health status, and ideally reliable and validated health status instruments, are frequently used to assess quality of life.

The types of economic analysis are well described by Gold et al.,⁵ and the following definitions are based on those descriptions. As mentioned in the above paragraph, a cost-effectiveness analysis relies on the concept of incremental costs and/or incremental outcomes. An incremental cost is the difference in cost incurred when a certain strategy is employed (e.g., implementation of a telemedicine program) versus an alternative strategy (or not implementing that strategy). Incremental effectiveness describes the improvement, or lack of improvement, when competing strategies are compared based on the target outcome (e.g., time from referral to biopsy for suspected skin cancers). Both costs and effectiveness are used to generate a cost-effectiveness ratio. For example, a study may find that a teledermatology program incurs an incremental cost of \$25 for each day saved between the referral date and the date suspected skin cancers are biopsied, when compared to the conventional referral process. The

additional cost of instituting the teledermatology program is weighed against the improvement in access to care. In some investigations, the strategy under study incurs lower costs and improved outcomes or, alternatively, higher costs and worse outcomes. In the former case, the strategy under study is considered “dominant” because it improves outcomes and does so at lower costs, while in the latter, the strategy would be considered “dominated” by the alternative. A cost-effectiveness ratio is not relevant in this case because the ratios are generated when one strategy incurs higher costs but greater effectiveness than the alternative.

A cost-minimization analysis is performed when the effectiveness of the competing strategies is equivalent or is considered equivalent. Simply put, a cost-minimization analysis is a cost analysis with the least expensive alternative considered to be the preferred strategy.

A cost-consequence analysis is essentially a spreadsheet-type depiction of costs and outcomes. Costs reside on one side of the ledger and outcomes on the other without any specific analysis. It is a relatively uncommon means of presenting economic data.

Cost-benefit analyses report the data entirely in currency terms. That is, the outcomes are converted into or expressed in monetary terms. Willingness to pay is one method of collecting outcome data in monetary terms. One may assess how much individuals are “willing to pay” to have access to a particular telemedicine intervention. Generally, cost-benefit analyses calculate incremental benefits minus incremental costs to yield a net benefit/cost of implementing the intervention.

Commonly Encountered Limitations of Telemedicine Economic Analyses

Quality of economic analyses depends on the quality of the cost and outcome data used. A major limiting factor in economic analyses of telemedicine is the availability, in terms of both quantity and quality, of outcome data. Few telemedicine studies have evaluated clinical outcomes in a rigorous manner and, in some cases, outcome data of conventional or usual care may be lacking. As would be expected in a nascent line of research, much of the existing outcome data in telemedicine are intermediate. With a maturing evidence base, more definitive outcomes such as clinical course, morbidity and mortality rates, and QALYs may become available to provide data for economic analyses. To use a non-telemedicine example, testing of lipid-lowering drugs first focus on the ability of these drugs to lower lipid levels (intermediate outcome) and then their ability to prevent myocardial infarctions or improve mortality rates (definitive outcome). Thus, the clinical relevance of the chosen outcomes for telemedicine research should always be considered. Ideally, the most

definitive outcome should be chosen. However, in some cases, only intermediate outcomes may be available for analysis.

Technology has a rapidly changing price structure. Any hardware used for telemedicine technology might be expected to undergo changing price structures in relatively short time spans. There is no simple solution for this dilemma; the prevailing market price at the time of the analysis should generally be used.

Labor costs may be profoundly affected by the adoption of computer algorithms or automated analyses. For example, the current practice of digital fundus photographs of the eye generally dictates that images are read by experienced reviewers, often optometrists or ophthalmologists. An initial review could be performed by an automated program, leaving only a small subset of images to be reviewed manually. This would have a profound effect on the labor costs and could conceivably change the conclusion one reaches about the economics of an intervention.

Telemedicine systems are often somewhat proprietary in that the equipment and/or mechanism used at one site may not be entirely same as those used at another site. This limits the generalizability of the analysis of any one system. Lack of standardization for image generation, transmission, and review adds to the inconsistency. Therefore, a complete and accurate description of the cost elements and healthcare delivery systems used in a particular analysis is necessary. Even the distance between the patient’s location and the site the patient would normally use for clinic-based care may have a profound impact on the conclusions reached by an economic analysis. Cross-country or cross-continent travel costs for clinic-based care averted by telemedicine will have a greater impact on the economic conclusions compared to travel cost averted cross-city.

Finally, the availability and accuracy of the cost elements are of obvious importance. To the extent that a direct cost can be attributed specifically to an intervention (e.g., the generation of a bill) the more confidence one will have in the data. As cost accounting requires more imputation or estimation, the confidence in the conclusions reached may be compromised.

The Teledermatology Paradigm STORE-AND-FORWARD TELEDERMATOLOGY

The store-and-forward teledermatology economic literature, though not extensive, serves to illustrate the concepts described above. One study analyzed a store-and-forward teledermatology system in a U.S. Department of Veterans Affairs setting, and the economic perspective taken in this analysis was that of the Department of Veterans Affairs.⁶ Thus, the costs borne directly by the department were evaluated. Costs were attributed and analyzed using a

microcosting technique. Microcosting involves a detailed measurement of all inputs consumed in a healthcare intervention.⁵ Costs were extrapolated to the consult volume managed by the dermatology clinic in a 12-month period. The analysis type was a cost-effectiveness study as it compared the costs and effectiveness of telemedicine to those of a conventional consult process. The measure of effectiveness or outcome analyzed was an intermediate outcome—time to intervention. For patients who did not require a clinic visit, time to intervention was defined as the time between referral and the time the consult was answered. If a clinic visit was required, it was defined as the time between the referral date and the date of clinic visit. *Table 1* illustrates the costs, effectiveness, and cost-effectiveness ratios generated by the study. Teledermatology yielded greater costs but also greater effectiveness. The resulting cost-effectiveness ratio showed that teledermatology incurred an additional cost of \$0.17 for each day of time to intervention saved when compared to conventional care. This ratio derives from the incremental cost of \$15.00 divided by the incremental effectiveness of 87.5 days. This would be a very favorable cost-effectiveness ratio if timely access to care is an important metric.

This study also employed a sensitivity analysis. Sensitivity analyses change the variables of interest across an expected or reasonably expected range of values and can also be used to change the economic perspective. In this study, the economic perspective of society was studied. When travel costs/loss of productivity costs and clinic visit costs were calculated based on a societal perspective, teledermatology was a cost-saving strategy across most variable ranges. This illustrates how important it is to define and accurately represent the economic perspective taken. In this case, the economic perspective determined whether teledermatology was a more costly strategy or one that was potentially cost saving.

A second study assessed patients with suspected skin cancer presenting to a skin cancer clinic in Spain⁷ as referred by store-and-forward teledermatology or a conventional letter-based referral system. Referrals for both modalities originated from a primary care

clinician. The economic perspective taken in this case was the societal perspective. Included were costs borne by the patients, such as travel costs for face-to-face care and working time lost (loss of productivity), in addition to healthcare system costs. Costs were itemized and compared between consult modalities. An intermediate measure of effectiveness similar to that in the previous study was used—time between referral from primary care and the date the patient presented at the hospital-based skin cancer clinic. The cost and effectiveness data for this study appear in *Table 2*. This cost-effectiveness analysis demonstrated dominance. That is, teledermatology incurred less cost and yielded greater effectiveness. The average cost of teledermatology, when compared to conventional care, was lower by €49.59 (~\$72) and was incrementally more effective by 76.31 days. The interpretation is unambiguous; teledermatology would be the preferred strategy based on the identified costs and outcome measure used in this study.

Another example in the store-and-forward literature illustrates a cost-minimization or cost analysis.⁸ This study first evaluated effectiveness by assessing the clinical course. Using a randomized trial design, subjects were randomized to store-and-forward teledermatology ($n = 272$) or the conventional referral process ($n = 236$). The conventional process resulted in scheduling into an in-person dermatology clinic visit. Clinical course was assessed between baseline (referral) and 4 months in both study groups by obtaining digital images at these two dates. Reviewing the serial digital images, a dermatologist rater blinded to randomization assignment rated the clinical course as improved, no change, or worse. Clinical course was found to be comparable for patients undergoing teledermatology consultation and those undergoing conventional consult process.⁹ Because effectiveness was equivalent, the economic analysis then became a cost-minimization analysis. The perspective taken was that of the U.S. Department of Defense. Lost productivity was included as this is a cost borne directly by the department. Store-and-forward teledermatology was found to be a cost-saving strategy, with an

Table 1. Cost and Effectiveness Data from the Whited et al. Study

CONSULT MODALITY	AVERAGE COST (\$)	INCREMENTAL COST (\$)	EFFECTIVENESS (DAYS)	INCREMENTAL EFFECTIVENESS (DAYS)	INCREMENTAL COST-EFFECTIVENESS RATIO
Conventional care ($n = 140$)	21.40		137.5		\$0.17 per patient per day of intervention saved
Store-and-forward teledermatology ($n = 135$)	36.40	15.00	50	87.5	

Table 2. Cost and Effectiveness Data from the Moreno-Ramirez et al. Study

CONSULT MODALITY	AVERAGE COST (€)	INCREMENTAL COST (€)	EFFECTIVENESS (DAYS)	INCREMENTAL EFFECTIVENESS (DAYS)	INCREMENTAL COST-EFFECTIVENESS RATIO
Conventional care (n=2009)	129.37 (~\$188)		88.62		Dominance of teledermatology over conventional care
Store-and-forward teledermatology (n=2009)	79.78 (~\$116)	49.59 (~\$72)	12.31	76.31	

average cost of \$340 per patient compared to \$372 for conventional care. Thus, from the Department of Defense perspective, teledermatology could be considered the preferred strategy as it yields equivalent outcomes at lower cost.

REAL-TIME INTERACTIVE TELEDERMATOLOGY

The real-time interactive teledermatology literature is more extensive than that of store-and-forward teledermatology. The following two examples serve to illustrate further the concepts introduced above. A large randomized trial performed a cost-benefit analysis taking the societal perspective.¹⁰ Respectively, this indicates that this trial analyzed the costs and benefits in monetary terms and took into account all relevant costs no matter who incurred the costs. The benefits of a teledermatology intervention were monetized as the cost savings due to reduction in referrals to dermatology and the subsequent savings in time and travel costs for the patient. Referring clinicians perceived that telemedicine provided an educational experience that would normally require formal training, with its associated cost. The monetary value of formal training averted by teledermatology was considered a benefit. This study included 102 subjects each in the teledermatology group and the conventional care group (outpatient dermatology consultation) and found that teledermatology yielded a net societal cost (i.e., total cost – savings + benefits) of £132.10 (~\$215) and conventional care yielded £48.73 (~\$79). Sensitivity analysis found that as the distance between the patient and the site of dermatology care increased, the difference in competing strategies became less until a “break-even” point was found at 205.8 km. A second study took the economic perspective of the healthcare sector and performed a cost-minimization analysis.¹¹ Only the costs borne by the healthcare sector were assessed and only the costs of each intervention were calculated because real-time interactive teledermatology and conventional care were considered to be equal in effectiveness. Although clinical outcomes are not a well-studied feature of real-time interactive (or store-and-forward) teledermatology, the assumption of equal effectiveness is a reasonable

one based on diagnostic reliability and patient management outcomes available in the literature. This study compared the costs incurred by a functional interactive teledermatology clinic to the records of conventional care visits at a dermatology clinic in a large medical center. Data were collected over an 18-month period, which included 451 unique teledermatology interventions and 47,434 conventional dermatology clinic visits. The total hourly operating cost for the teledermatology practice was \$273.66 and for the conventional practice was \$346.04. From the perspective of the healthcare system, real-time interactive teledermatology was the less costly strategy.

Real-time interactive teledermatology literature includes other examples of cost-benefit or cost-minimization analyses. The conclusions vary from teledermatology being a cost-saving strategy, to a cost-neutral strategy, to one that incurs greater costs.¹²⁻¹⁸

Conclusions

The small number of studies assessing store-and-forward teledermatology has shown that it is at least a cost-effective strategy and has demonstrated dominance in one report.⁶⁻⁸ The literature on real-time interactive teledermatology has run the gamut from teledermatology being a cost-saving strategy to one that incurs greater costs.¹²⁻¹⁸ A notable deficit in the real-time interactive literature is a true cost-effectiveness analysis.

As illustrated above, the economic perspective taken often impacts a study’s conclusions. What may be more costly to the healthcare system may result in cost savings to society. Other common features that influence a study’s results are travel distance required for conventional care, consult volume, and technology costs. These variables are often used in sensitivity analyses to determine a break-even point, or to predict the point at which an intervention would become less costly or acceptably cost-effective. When teledermatology is a cost-saving strategy it is often considered as due to averted travel costs, less employment time lost, and similar issues that impact patient-centric cost elements. This often implies that a societal

perspective has been taken by the analysis, but in some settings, such as the U.S. Department of Defense and the Department of Veterans Affairs, these costs are incurred, in whole or in part, by the healthcare system. As such, they often become an important factor in the economics of teledermatology in these healthcare systems. In summary, important features when reviewing or designing an economic analysis include (1) the type of economic analysis undertaken, (2) a complete cost-accounting of relevant cost elements, (3) a description of the economic perspective taken, and, when possible, (4) reporting the results of a sensitivity analysis that considers a plausible range of costs, benefits, and outcomes.

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Disclaimer

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