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ELEMENTS FOR ASSESSMENT OF TELEMEDICINE APPLICATIONS

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Abstract

Objectives: As an initiative of the International Network of Agencies for Health Technology Assessment, an approach to assessment of telemedicine applications was prepared to assist decision makers who are considering introduction and use of this technology.
Methods: Review and commentary drawing on published assessment frameworks and reports of primary evaluations of telemedicine, with particular reference to experience in Finland and Canada.
Results: Elements of the approach included development of a business case (considering population and services, personnel and consumers, delivery arrangements, specifications and costs); subsequent evaluation of the telemedicine application; and follow-up (covering the domains of technical assessment, effectiveness, user assessment of the technology, costs of telemedicine, trials, economic evaluation methods, and sensitivity analysis).
Conclusions: Decision makers should link introduction of new and often costly technology to appraisal of its feasibility, followed by evaluation of the application, including longer term consideration of its sustainability and impact on the healthcare system. As the effectiveness and efficiency of telemedicine applications will often be strongly influenced by local issues, results of assessments may not be generalizable.

Keywords: Telemedicine, Assessment, Health policy

Telemedicine has been defined as "the use of electronic information and communications technologies to provide and support health care when distance separates the participants" (11;22). There are great expectations for telemedicine, which in principle can benefit many players: local authorities (cheaper specialized services); hospitals, primary healthcare centers (improved service, increased supply of expertise); patients (changes in state of health and quality of life, savings in costs and time); healthcare personnel (increased proficiency); employers (reduced absenteeism from work); and the social insurance system (reduced reimbursements).

The International Network of Agencies for Health Technology Assessment (INAHTA) decided that telemedicine was a suitable topic for a project, in view of increasing interest in its application and significance to healthcare systems. In particular, there appeared to be a need for an overview of factors related to telemedicine assessment if the technology was to be adequately considered by decision makers and appropriately introduced and used. Ideally, assessment should provide a broad description of telemedicine for decision

makers, covering technical, clinical, economic, ethical, legal, and organizational issues. In practice, assessments have been constrained by availability of data, timing of policy and administrative decisions, shortage of evaluators, and inertia within healthcare systems.

In this paper we provide a description of the assessment frameworks that formed a major part of this international collaborative project (15). This proposed assessment approach drew on earlier reports and aimed at a more comprehensive synthesis of information to give fuller directions to decision makers and evaluators.

METHODS

The approach to assessment of telemedicine applications was developed through consideration of published assessment frameworks and reports of primary evaluations. There was particular reference to reports that had been prepared by the authors and their colleagues as part of health technology assessment programs in Finland (16) and Canada (8), which have formed the basis of primary studies of telemedicine applications. In addition, use was made of publications that have discussed telemedicine as a target of assessment (11;13;14). The focus was on the use of telemedicine in routine health care, rather than in experimental situations or feasibility studies.

The report was developed through iterative input from the organizations involved. A draft for comment was made available to all members of INAHTA and to persons with experience in telemedicine in Finland and western Canada. Responses obtained from these sources were taken into account during review and revision of the document.

General Concepts

In building the framework, steps considered included development of a business case for the telemedicine application, initial assessment of its use, and longer term assessment as the application moves into routine use. A key feature is that at each stage the application is compared with a situation where telemedicine services are not available. This is of considerable significance for decisions on the appropriate use and introduction of telemedicine. Telemedicine may have favorable attributes, but the existing system may serve the population well and be capable of improvement. Comparison should include the present (non-telemedicine) system, the present system when upgraded, and the telemedicine alternative.

The telemedicine option should be sufficiently mature for assessment to be meaningful. Prototypes or telemedicine practices that are not fully integrated with the healthcare system can be assessed in pilot studies, but these can give only an interim indication of the feasibility of a telemedicine application.

The introduction of telemedicine applications may result in substantial changes to healthcare practices for that part of the health system to which the technology is applied (22). The changes in the processes do not only affect healthcare costs but also may change the structure of personnel used, legal responsibilities (20), and the place and nature of the interventions.

The nature of individual telemedicine projects will vary, and each case will need to be considered in detail. Investments in telemedicine will be accompanied by changes in patterns of care—in quality of service, time, and availability. There may be consequent changes in health outcomes and patient satisfaction. Some issues will be relatively specific to the health authority or other purchaser, so that local data and circumstances will need to be considered. In the wider context, there are country-specific variations in the health systems that make it difficult to generalize the results from one country to another.

Definitive assessment of a telemedicine application may take a considerable time and be complicated both by changes to the technology and to the healthcare system. This climate of

Table 1. Impediments to Development of Telemedicine Applications

Lack of clarity regarding definitions and specifications of telemedicine—what telemedicine is and what is truly needed in various applications.
Lack of appreciation of the need to consult with healthcare professionals and others and to consider reorganization of services that are consequential to adoption of telemedicine.
The majority of proposed telemedicine applications have not progressed beyond the pilot project stage. Economic and other evaluation of most applications remain very limited.
Short lifetime of many equipment components and the speed of change of some technology.
Lack of resolution as to how physicians should be reimbursed for services they provide using telemedicine. This may be more significant in private-oriented healthcare systems.
An unmet need to ensure interconnectivity between different regions and institutions. It is not clear that all technical issues have been resolved.
Telecommunications standards are not consistent across individual healthcare systems, so there is variation in the transmission costs and capability that apply to various regions.
Uncertainty that agreed equipment specifications will be met by suppliers. Some equipment may remain in the developmental phase for longer than expected.
Concern regarding provision of effective routine troubleshooting support.
Issues relating to licensing of medical staff and other operators.
Concerns that introduction of telemedicine might lead to disruption of established referral patterns, linked to a possible lack of control of healthcare services.
Questions of availability of specialist referral advice at major centres are not fully resolved, especially for real time applications. There are various issues related to relationships between different levels of government.
Health authorities have faced financial and administrative pressures; detailed consideration of telemedicine systems may be pushed aside by other priorities.
Telemedicine systems require assessment and ongoing collection of data for administrative purposes, but local resources for these tasks are minimal
Some health authorities, in part because of their proximity to major centers, see no real advantage in proceeding with telemedicine systems at this stage.

continuing change often suggests the need for a series of comparatively rapid, less detailed evaluations to provide decision makers with timely interim advice.

Making the Case for Telemedicine

There have been a number of impediments to creation of a fully developed "telemedicine society," some of which are summarized in Table 1 (1). These are matters that will need to be considered by managers who are introducing this technology. The nature of these issues vary considerably. Some relate to technical details and cost of equipment and data transmission, which may be expected to resolve as improvements to the technologies concerned become available. Others concern personal relationships and professional responsibilities, and may require substantial discussion and negotiation. Prior to any detailed assessment, those seeking to introduce telemedicine will need to give general consideration to a number of points so that a business case can be made for acquiring this technology. It will be necessary to specify both clinical requirements and the technology being considered for adoption. The specification will include a clear outline of the application and of equipment, staff, and other resources. Introduction of telemedicine will raise some technical issues related to data transmission and equipment. There will be a need to obtain assurance that available hardware and software can provide the performance required, at a realistic cost, and that adequate technical support will be available. Validation of specifications and performance under local conditions are major issues.

Consideration of the project specifications should help to determine whether a particular telemedicine application is appropriate or if telemedicine is needed at all. Managers should be seeking strong grounds to presume that the proposed application will be sustainable

(capable of providing an effective service continuously rather than operating only as a demonstration project). A suggested initial checklist is shown in Table 2.

To realize the potential benefits from telemedicine through time-related gains in efficiency, planners and managers will need to put in place changes to organizational structure and administrative procedures. Most of the benefits of telemedicine can be realized only when systems are widely used within the organization and/or between organizations, i.e., the technology is accepted by patients, healthcare professionals and managers. Several telemedicine applications may need to be put in place within a telecommunications network, with shared videoconferencing and other facilities, before overall efficiency is achieved.

Many of the issues on use of the technology will relate to changes in work practices and routines (22). Active consultation with all staff who will be affected by introduction of telemedicine and use of their expertise in developing programs should be priorities. Availability of a person to take responsibility for coordination of telemedicine applications and their assessment is essential. The coordinator must have a clear understanding of the overall delivery requirements of the healthcare system and be responsive to the needs of healthcare professionals and their clients (8).

Both "top down" and "bottom up" approaches to the planning and implementation of telemedicine applications have been suggested. Yellowlees (23) suggests that management and support of telemedicine projects should be from the bottom up—clinicians may be more aware about the technical properties of the telemedicine alternative and thus can develop the new system to meet the needs of the local population. However, the experiences from Norway suggest that the importance of the top level in the development of the telemedicine system increases once the pilot project is widened to other sites in a region or to the whole country (17).

ASSESSMENT OF TELEMEDICINE APPLICATIONS

General Considerations

Many issues in telemedicine assessment are common to evaluation of healthcare programs in general. The nature of the assessment will depend on the context in which it takes place and the complexity of the telemedicine application. Context-specific features may include sources and scope of data, organization of services, case mix, and social values. For example, while assessment of a video conferencing facility can be made within one subgroup of a specialty, a hospitalwide picture archiving and communication system (PACS) requires a much more holistic approach, covering the whole hospital.

Guidance for assessment has been provided in frameworks formulated by a number of authors (8;11;13;14;16;19). These make provision for detailed evaluation of a number of attributes, although to date much more limited assessment has been undertaken in practice. In the discussion presented here, particular reference is made to the framework summarized in Table 3, which draws on work undertaken by the Finnish Office for Health Care Technology Assessment (FinOHTA) (16). This general hierarchy for evaluation of telemedicine applications to some extent follows that of Fineberg et al. (7), in giving an indication of stages to be considered in addressing the efficacy and effectiveness of the technology.

Technical Assessment. This assessment will include the technical quality of the images after a transmission and whether the transfer of all data was made successfully. Technical accuracy studies show whether telematic transmission is feasible and whether the method fulfills technical quality requirements. Some of these issues may be picked up through routine quality assurance protocols and in the development of a business case considered earlier.

Table 2. Questions to Consider in Development of a Business Case for Telemedicine

Population and services	
What applications are being considered?	By specialty By administrative task
What are the current delivery arrangements for each specialty?	Approximate level of demand Local and remote healthcare providers Referral arrangements
Personnel and consumers	
Who is to operate/use the telemedicine application(s)?	Local healthcare providers—will there be changes in roles and responsibilities? Remote healthcare providers—have changes in relationships to remote providers been identified?
Has there been consultation with all healthcare staff involved? Is there acceptance?	Consider views of all staff
Should there be wider publicity and consultation regarding the telemedicine services?	Consider: Contact with patient groups, general public Level of community acceptance
What training programs need to be put in place?	Consider qualifications and training needs for all staff who will be involved with the telemedicine application
Delivery arrangements	
How many sites will be using telemedicine?	Specify the applications at each site Consider sequence/timing of introduction of telemedicine at each site; there may be advantages in phased introduction
Has scheduling been addressed, at least at a preliminary stage?	Consider scheduling of teleconsultation sessions within region/service Check/negotiate availability of remote providers
Is real-time telemedicine essential for local needs, or might store and forward options be adequate?	Consider if immediate availability of information is important for clinical and administrative needs Consider factors that would ensure consistent real-time services
What are the storage requirements for data from use of telemedicine applications?	Cost and flexibility of storage requirements
What back-up arrangements will apply should the telemedicine system fail? Have data security and privacy issues been considered?	Need to develop contingency plans
Specifications and costs	
What are the specifications and projected costs for purchasing and maintaining telemedicine equipment? Will they apply fully to the goods that are to be purchased?	Consider how specifications will relate to the application in question and the needs of those using it Ensure availability of desired equipment Bear in mind that equipment will need replacement, perhaps after 3 years Clarify cost and details of maintenance arrangements
What are the mode and costs of communication?	How do these relate to expected levels of use of the system?
Who is going to invest in tele-communication joint infrastructure?	Is this to be a responsibility of government or operators?
Will the telemedicine application cover all use of the service in question?	If current arrangements are to stay in place for some cases, consider resource and organizational needs and costs
How will changing delivery arrangements affect cost?	Changes to personnel and to supplies will have consequences for costs

(Continued)

Table 2. *(Continued)*

Are there other less expensive telemedicine options?	Consider potential for Web use, for example, in telemedicine-education applications Other telemedicine approaches (e.g., telephone, secure fax, e-mail) may be good options for some applications
Have issues on funding/reimbursement for use of telemedicine applications been resolved?	These may involve wider policy matters Managers and users will require assurance on reimbursement issues Consider that the benefits (e.g., saved traveling costs) may not come to the payer of the telemedicine service

The technical properties influence the sensitivity and specificity of telematic diagnostic methods. One commonly used method to test the diagnostic quality is to perform a receiver operating characteristic analysis, where the diagnostic accuracy of transmitted images is compared with that of the same images sent and viewed by a conventional method (18;21). Aspects of technical accuracy and diagnostic quality require evaluation and resolution before consideration is given to assessment of clinical effectiveness.

Effectiveness. The differences in mortality or indications of morbidity (e.g., duration of sick leave) that occur as a result of introducing telemedicine are often very small. Evaluation data are more readily obtained for diagnostic and therapeutic effectiveness than for changes in health status. Those making decisions concerning telemedicine commonly have to rely on surrogate measures of effectiveness that may have tenuous links to health status indicators. Appraisal of the influence of telemedicine on patient management often continues beyond the pilot project stage. Users and funders of telemedicine services may wish to undertake ongoing monitoring of patient management, possibly linking such measures to quality assurance programs.

Measurement of changes to patient outcomes poses major challenges to those assessing telemedicine applications. In general:

- Availability of administrative and other data for conventional services may be limited;
- Differences in outcomes between the telemedicine and conventional options may be modest, while numbers of subjects may be small and the power of the study low;
- There may be changes to telemedicine technology; and
- There may be changes to the conventional (nontelemedicine) technology and to the structure of the healthcare systems.

Study Design. The strength of evidence of a telemedicine study depends to a large extent on the study design (see trials, Table 3). While large randomized controlled trials (RCTs) offer the strongest evidence for decision making, randomization may be difficult in some telemedicine studies. A further limitation on the use of RCTs in telemedicine, as argued by McDonald (12), is that in reality they will be undertaken only during the pilot or early routine use of an application. As with other healthcare technologies, RCTs will be used in telemedicine to assess the efficacy of the technology. Such RCTs may not be widely generalizable and will not necessarily be more than a general guide to the effectiveness of the telemedicine application, should it prove to be sustainable and move into long-term routine use.

The reality in the evaluation of telemedicine is that weaker study designs may have to be used. As a result, decision makers must be cautious in the degree of inference from

Table 3. Assessment of a Telemedicine Link Between a Remote PC Unit and an SC Unit

Items	Symbols	Measurement topic
Technical assessment		
Technical quality of image (and voice) transfer		Time, luminance, resolution Sensitivity, specificity, ROC, rate of successful transmissions
Reliability, validity and other characteristics		
Effectiveness		
Diagnostic quality	E	Sensitivity and specificity of diagnosis
Changes in health-related quality of life	E, U	e.g., QALY, HRQOL profiles
Clinical changes in health	E	Survival, symptoms
Changes in management process in hospital		Clinical pathway, improved quality of care
Increasing know-how in PC		Decreased utilization of consultations, improved quality of primary care
Nonhealth outcomes of a patient		Certainty, access of care, equality
User assessment of the technology		
Physicians		User questionnaire from quality, usability, and satisfaction
Nurses and other staff		User questionnaire from quality, usability, and satisfaction
Patients (if relevant)		User questionnaire from quality, usability, and satisfaction
Costs of telemedicine		
Investment costs in PC and SC	FC	Direct cost; e.g., equipment and network
Monthly user charge of equipment in PC and SC	FC	Direct cost; rental cost of lines, maintenance (10–15% of capital costs)
Costs of used communication lines in PC and SC	VC	Direct cost; user charge per hour
Wages of doctors and other staff in PC and SC	VC	Direct cost; time used on telemedicine
Education of the technology (PC and SC)	VC	Direct cost; education of personnel and support services
Other relevant costs in PC and SC	FC or VC	Direct cost; room, energy, administration
Costs of a patient (and close relatives)		Direct cost; traveling and domestic costs, other medical costs
Lost working and leisure time of a patient		Indirect cost; time away from work
Intangible costs		Indirect cost; value of death, pain, and/or worsened HRQOL
Total costs (TC) = fixed costs (FC) + variable costs (VC) + other direct costs (+ possible indirect costs):		
Trials		
Randomization		Most preferred
Before and after comparison within hospital		
Control groups		
(Experimental or nonexperimental analysis)		
Economic evaluation methods		
Cost or effectiveness analysis (CA, CMA, EA)	TC or E	Only TC or E measured
Cost-benefit analysis (CBA)	TC-E, TC/E	Both TC and E in monetary units

(Continued)

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Table 3. *(Continued)*

Items	Symbols	Measurement topic
Cost-effectiveness and cost-utility analysis (CEA, CUA)	TC/E, TC/U	E in natural units or preferences and U in utilities
Sensitivity analysis		
Distance		Distance between cooperative sites
Number of patients		Patient load in both sites
Duration of the investment		Years of utilization
Effects of changes in technology in the future		e.g., improved technical quality and shortened duration of transmissions

***Source*:** Ohinmaa et al. (16).
Abbreviations: CA = cost analysis; CMA = cost minimization analysis; E = effectiveness; EA = effectiveness analysis; PC = primary care; QALY = quality-adjusted life-year; secondary care; TC = total costs; U=utility.

the assessment results published in the field. Telemedicine assessments have so far been on stronger ground in considering effects of the technology on time-related consequences of healthcare services and on organizational issues.

Quality-of-life Measures. The relatively short-term intervention of most telemedicine applications and the indirect nature in health effects are impediments to the long-term measurement of outcomes, including quality of life (QOL). In an application such as teleradiology, where many types of conditions are covered, a disease-specific instrument cannot be used. Generic measures developed to be applicable in most diseases may be more useful. At least in the short term, QOL outcomes may be more likely to relate to time-related aspects such as differences in waiting times or travel requirements consequential to use of the new technology. Useful indications of possible effects of QOL may be obtained from preliminary surveys during feasibility studies (5).

Other Outcomes. Telemedicine may also have substantial educational effects in primary care (Table 3). For example, during videoconference consultations a specialist can guide a general practitioner (GP) to make new types of examinations on a patient. The GP can hear about new treatments or other medical information. Bergmo (2) has included educational effects in an economic analysis of teleconsultation in otorhinolaryngology. The educational/ training effects of telemedicine may have an influence on the sustainability and costs of a specific application as it moves from the pilot project phase into routine care (such effects may tend to decrease use of telemedicine). A contrary trend is that establishing telemedicine may lead to previously unmet demand for services (9).

Costs of Telemedicine

Table 3 shows the checklist of costs that are applicable in most telemedicine projects. Once the use of resources in natural nonmonetary units has been measured, the quantity units of resources are multiplied by their monetary values. In the valuation, market prices should be used. The cost estimates obtained from accounting may not reflect the real opportunity cost of used resources. For example, buildings, land, and equipment may have been written off in the accounting but will have opportunity cost in the use of other projects (3).

The telemedicine application and the alternatives with which it is compared may have different distributions in time of costs and benefits. It has been assumed that while current investment costs can be high, the reduction in prices in the future, together with decreased need for secondary care (through the educational effect on primary care), will significantly decrease the lifetime costs of a project.

Types of Cost. Costs are categorized as direct, indirect, and intangible. Most telemedicine projects are aimed at reducing the expenditure related to the transaction of specialized medical services.

Direct costs can occur either within health care or to the patient. These may include costs of travel, other health care, and arranging home help (Table 3). Direct healthcare costs include those directly due to the application of telemedicine or the conventional alternative. The investment costs of equipment and line charges constitute a great deal of the direct (and total) costs of telemedicine in many specialties. Both primary care (PC) and secondary care (SC) units must invest in machinery, software, accommodation, and networking (fixed costs [FC]). In addition, fixed costs include the rental cost of the network, some salaries and wages, and possibly administrative expenses of the hospital/center. Variable costs (VC) include those that vary according to the level of service, such as supplies, drugs, and fees for service. Since in most telemedicine projects healthcare professionals are working only occasionally in the project, salaries and wages can be counted as variable costs.

The analysis of costs is commonly undertaken using a 1-year period. The annual fixed costs are calculated by dividing the investment costs by the utilization time of the equipment and adding the other annual fixed costs. The share of fixed costs per patient is calculated on the basis of the annual case load. If the variable costs do not change according to the number of patients per year, the total direct healthcare costs per patient (TC) is calculated by adding the fixed cost and variable cost per patient.

Indirect costs are used to denote the time of patients (or their families) consumed or freed by the program (Table 3). The intangible costs include the value of death, pain, and health-related quality of life (HRQOL) (6). They are valued either by using monetary values or by using economic and psychometric scaling techniques.

At this stage in the assessment of telemedicine, consideration of indirect costs has not been a major factor. However, in the study of Halvorsen and Kristiansen (10), indirect costs played an important role when the decision rule for a teleradiology service was made.

The costs of telemedicine are crucially dependent on the degree of utilization of the equipment. If the primary care center is able to use video conferencing for many types of consultations, the share of the purchase cost of the equipment (FC) in the total costs will be reduced. In principle, a high degree of equipment utilization (e.g., links with several PC centers or a large number of applications) at an SC unit offering telemedical services reduces the per-consultation costs of telemedicine. Much depends, however, on the number of personnel required to produce the service and on the time used for telecommunication, that is, on the variable costs of a project. As a rule of thumb, the shorter the distances between cooperative parties, the higher the utilization of the equipment should be to make the investment beneficial. A good example is PACS, where system utilization must be very high to make the investment realistic.

These questions are analyzed in the framework of marginal and incremental costs. The incremental cost (or benefit) refers to the extra cost when an additional project is established beside the old ones (6). In every investment, the incremental benefits should exceed the incremental costs of the project in the long run (8).

Economic Evaluation Methods

Table 3 makes reference to effectiveness analysis, cost minimization analysis, cost-effectiveness analysis (CEA), cost-utility analysis (CUA), and cost-benefit analysis (CBA). Cost minimization has been the most frequently used approach in the field of telemedicine, with the assumption being made that the efficacy or effectiveness of the telemedicine and nontelemedicine options are the same.

The effectiveness measures used in CEA include both natural unit measures (such as life-years saved, reduction in sick leave, and morbidity) and HRQOL measures other than utility measures. The results of CEA and CUA are shown as the ratios TC/E and TC/U in Table 3. For meaningful comparison, it is important to analyze the additional costs that one program imposes over another, compared with the additional effects, benefits, or utilities it delivers, using incremental cost-effectiveness ratios (6).

Implementation of Economic Analysis to Telemedicine

Although the basic theory of economic evaluation is reasonably clear, its implementation to telemedicine is less certain. Difficulties can be found in the estimation of both the effectiveness and the cost side of the analysis.

On the cost side, the changing technology hinders the estimation of costs, since successive versions of equipment have different, usually decreasing, prices. As McIntosh and Cairns (14) have pointed out, changes in access to care, consultation, and referral patterns and number and skill mix of staff may have significant effects on costs. Since such difficulties are largely connected to the uncertainty of the environment in which telemedicine is used, these questions can partly be addressed by undertaking a sensitivity analysis of study results.

Sensitivity Analysis

Much of the practical interpretation of the economic evaluation results revolves around sensitivity analysis in which cost and outcome factors are simulated under various basic assumptions. In this way, some allowance can be made for future developments. The four broad areas of uncertainty in the analysis relate to variability in sample data, generalizability of results, extrapolation, and analytical methods (14).

In the assessment of telemedicine, difficulties can be found in all of these areas. For example, available data may not be representative of the usual patients who access the service and how well they comply with usual practice throughout a whole health system. In telemedicine, sensitivity analyses could be done, for example, by location of primary care unit, number of patients, case mix, useful life of investments, and type (price) of investments.

Summaries of Monetary and Nonmonetary Factors

Any realistic appraisal of a telemedicine application will need to consider a range of both quantitative and qualitative factors. An approach that has been suggested is social audit analysis (4). With this approach, monetary and nonmonetary factors in different areas of impact can be brought together for comparison, with additional detail and values being included as assessment results become available (Table 4).

Such analysis could include costs and benefits to specialists, referring physicians, other healthcare professionals, patients and their families, and healthcare administrators and funders. Particular benefits that apply to each group of major participants in the telemedicine application can then be considered. Consideration can be given to providing appropriate weightings for intangible benefits, in association with those for which monetary valuations are available. Weightings for the various factors would take into account the environment and priorities and values held by policy makers (8).

DISCUSSION

Introduction of telemedicine systems in routine health care has major implications for healthcare delivery. Duties and status of health professionals, standards of service, access to and efficiency of services, and ultimately population health status can all be expected to be affected by the use of this technology. Given the potential breadth of this influence

Table 4. Summary of Impact for a Telepsychiatry Application

Area of impact	Effect on consumer (patients & family)		Effect on psychiatrist		Effect on referring physician/local service provider		Effect on payer (provincial government)	
	Monetary	Nonmonetary	Monetary	Nonmonetary	Monetary	Nonmonetary	Monetary	Nonmonetary
Treatment/ outcomes	Effects through changes in length of treatment	Effect on health status Increased access to care; change in support	Psychiatrist can treat more patients	Intervention before severity of illness increases Effects through travel	More patients can be treated	Assistance/ education in management Ability to clarify information	Increased treatment costs	Improved coverage of population
Travel	Decreased travel expenses and lost work time	Inconvenience and stress of travel		Decreased travel, foregone professional tasks			Decreased travel costs for psychiatrists	
Waiting	Potential decreased costs through lost work time, etc.	Potential for more rapid support, decreased severity of illness	Uncertain	Uncertain	Uncertain	Shorter term management prior to consulation Faster decisions on treatment	Possible influence on cost of services	Potential for improved health status

and associated expenditure, it is of some importance that telemedicine applications are adequately assessed so that decisions on their implementation and use can be suitably informed. Decision makers should link introduction of new and often costly technology to appraisal of its feasibility, followed by evaluation of the application, including longer term consideration of its sustainability and impact on the healthcare system.

Data are required on the long-term impact of telemedicine on health outcomes, costs, and organization. Consideration will also be needed as to how to continue to obtain measures of clients' and health professionals' opinions and preferences on a long-term basis. Both data requirements and logistics for longer term economic appraisal are likely to be demanding. There will be a need for reliable administrative data, systemwide tracking of patients' records, and high quality research on measures of patient outcome and preferences (9).

Healthcare providers and funders have a need for assurance that telemedicine services for which they are responsible are of adequate quality. Quality can be defined broadly to include those characteristics, other than time, that influence the experience obtained from use of telemedicine. Quality will include easily defined measures, such as the standard of an x-ray image, but may include wider issues such as the degree of personal contact between a medical practitioner and a patient (8). Quality problems with telemedicine might include both overuse and underuse of care (for example, inappropriate application or failure to refer patients for necessary services) (15). These issues are closely connected to equity questions and the funding of health care.

The assessment framework discussed here gives an approach for use by decision makers with responsibilities for the procurement and use of telemedicine applications. It has been found useful as a guide to assessments undertaken in Finland and Canada. However, as noted elsewhere (8), use of such frameworks requires some commitment to systematic collection of data and to the comparison of telemedicine applications with alternatives. The extent of evaluation will depend on resources and administrative requirements. A dilemma here is that typically agencies operating or funding telemedicine may have few resources for assessment, and yet local evaluation may well be highly desirable in view of the importance of local healthcare arrangements. In addition, the generalizability of evaluation results, especially between countries, may be limited.

Assessments of telemedicine applications reported in the literature are still very limited, and few have approached the level of detail and rigor implied by use of the frameworks proposed in the present paper. A systematic review of the literature from 1966 to 1999 (15) was able to locate only 29 studies that both compared telemedicine with a nontelemedicine alternative and reported clinical, economic, or administrative outcomes. Some kind of economic analyses were reported in 19 of these studies and were mainly variants of cost analysis.

It has been suggested that the topics listed under the framework in Table 3 should all be considered at least in some qualitative sense, even if fuller studies are not feasible (8). If these various issues are not addressed, healthcare consumers, administrators, and professionals will run the risk of having to use telemedicine systems that are not responsive to their needs.

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