A MODEL FOR THE ASSESSMENT OF TELEMEDICINE AND A PLAN FOR TESTING OF THE MODEL WITHIN FIVE SPECIALITIES

Arto Ohinmaa, Jarmo Reponen and Working Group

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ACCOMPANYING NOTE

The great impact of health care on public health and the national economy, as well as the successes of systematic assessment of the methods of health care in other countries prompted the establishment of the Finnish Office for Health Care Technology Assessment (FinOHTA) at the beginning of 1995. Operating under the National Research and Development Centre for Welfare and Health, FinOHTA aims at promoting national interdisciplinary research into health technologies and at setting up and utilising networks of experts experienced in technology assessment. The second main function of FinOHTA is to obtain information about technology assessments and the state of the art in Finland and elsewhere, and to relate the message extracted from this information to Finnish conditions and disseminate it to health care users, professionals and decision-makers. FinOHTA does not generally carry out technology assessments by itself; instead, its role is one of promoter, coordinator and provider of research funds. FinOHTA collaborates with the International Network of Agencies for Health Technology Assessment (INAHTA) and its member organisations in disseminating information and coordinating technology assessments.

The methodology of health care is evolving very rapidly. New diagnostic, therapeutic and rehabilitative methods are being continuously introduced. The trend in health care costs reflects the adoption of not only more efficacious but often more expensive methods. And yet, the health care system has to cope on existing resources and, in many cases, even to cut spending. The question arises whether all methods - present as well as those to be introduced - are really effective, cost-effective as well as socially and ethically acceptable. Public debate is often concerned with relatively new and/or expensive technologies. This is also true of telemedical applications which appear to develop at a rapid pace in Finland. The progress in telemedicine may be mainly due to the intensive development of the requisite infrastructure, especially data net services, software systems and user interfaces, in recent years. With the concurrent fall in prices, the technical and economic obstacles to telemedical applications have diminished considerably. At present, press comments and other opinions concerning these applications are mainly positive despite a lack of evidence on the wider effects of telemedicine. Assessments in this sector are, therefore, urgently needed. Consequently, FinOHTA has launched activities that will hopefully produce relevant research data as soon as possible to support rational decision-making.

FinOHTA hopes that the construction of the envisaged model for the assessment of the effects of telemedicine and any subsequent model-derived data on the effects of telemedical applications will prove an asset to decision-making. We also invite readers who have ideas or suggestions about the model presented in this report or other aspects of telemedicine to contact FinOHTA or the Working Group, for the advancement of the assessment of telemedicine.

Helsinki, 24 April 1997

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CONTENTS

PREFACE

New operational models are being adopted within health services to improve the quality and efficiency of care. The operational environment has changed substantially in recent years, partly as a result of technological advances, partly in response to the tightening of the overall economic situation. Knowledge and mastery of new innovative approaches are needed to cope with this change.

Telemedicine (distance medicine, distance nursing, distance care) is one of the fastest-evolving new technologies in medicine worldwide. Although the first experiments in telemedicine were already carried out at the beginning of this century after the telephone had been invented, the real breakthrough has taken place during the past decade with the developments in telecommunications and information technology. Finland is particularly well placed to develop telemedicine, thanks to her comprehensive health care system, high level of know-how and advanced communication technology.

In Finland, expectations have been high especially about the development of telemedicine as part of functional service chains. Objectives related to health care have been stated in the Information Technology Strategies for Health Care published by the Ministry of Social Affairs and Health in 1996 and in the report "Information and Communication Technology in Health Care" commissioned by the EU Parliament and prepared by the National Research and Development Centre for Welfare and Health. A national programme on the use of multimedia in health care is currently being drafted under the auspices of the Ministry of Trade and Industry. Furthermore, Finland hosted the first Nordic congress in telemedicine.

Since telemedicine is a new technology, its optimum fields of application have not been fully defined. It has been tested in almost all major medical specialities but so far it has found productive clinical use in only a few disciplines, including radiology, psychiatry and otology. With decision-makers and health care professionals facing conflicting pressures of procurement decisions and service development, information is needed. Critical appraisal is required to determine the primary areas of application in terms of economy and effectiveness.

The Finnish Office for Health Care Technology Assessment (FinOHTA) considers the assessment of telemedicine to be of major importance. The Health Care District of Northern Finland has practised telemedicine for many years. The first experiments were made with X-ray images back in 1969, and teleradiology has been a regular feature of the District's operations since 1991. Today, there is a clinical network encompassing several institutions. Telepsychiatry was started in 1995 and telesurgery in 1996. Teleophthalmology should proceed to a clinical phase during 1997. The Health Care District of Southwestern Finland is also actively developing telemedicine. Telepathology was started experimentally in 1995 and has now reached the clinical phase. Close cooperation among the primary health care centres and hospitals in the District is also an important objective of the development activity.

The above health care units conducted a FinOHTA-funded preliminary survey of the assessment of telemedicine in 1996. The project engaged both a telemedicine expert and a health economics expert. The survey outlined the application of the assessment process to a new field and to a concrete environment. The survey aimed at producing models and guidelines for the elaboration of assessment criteria and for the planning of research and development within telemedicine. It is hoped that the present report will contribute towards a uniform set of assessment criteria in Finland and guide decision-making.

Oulu, 15 February 1997

Jarmo Reponen *Arto Ohinmaa*

ABSTRACT

Telemedicine is one of the fastest-growing fields of medical technology. Far-reaching goals have been set for it, extending from savings in expenditure and a more equal supply of specialised services to boosting the proficiency of health care personnel. Telemedical applications use telecommunication networks, which makes them an important element in the networking of the health care sector. In this sense, telemedicine should be regarded as part of the wide field of information and communication technology and as part of the establishment of a Finnish information society. In addition, telemedicine is integral to uninterrupted clinical management pathways, and this strategic tool has been used, for instance, in the medium-term survey of municipal profiles in the Health Care District of Northern Finland.

The preliminary survey for the telemedicine assessment project was carried out in 1996 jointly by the Health Care Districts of Northern Finland and Southwestern Finland, and FinOHTA. The participants of the project include the Departments of Radiology, Psychiatry, Surgery and Ophthalmology of the Oulu University Hospital and the Pathology Unit of the Turku University Central Hospital. The clinical research will be conducted independently by each participating clinic. The cost-benefit and cost-effectiveness analyses will be performed by one investigator. The parameters have been made as commensurate as possible among the various subprojects. With this objective in mind, a common framework of assessment (a recommendatory list of themes to be addressed in the assessment) has been prepared, to be presented in the present report.

The project of telemedicine assessment has five foci, some of which are concerned with clinical work and some with the transfer of examination data. For *telesurgery*, the use of video conferencing in the context of first and follow-up visits of mainly orthopaedic patients is studied. The patients will be randomised between a video conference held at a primary health care centre and a visit to the outpatient clinic of a central hospital. As for *teleophthalmology*, the follow-up of glaucoma and retinopathy patients will be assessed. Some of the examinations will be carried out at the Department of Ophthalmology of the Oulu University Hospital while some of the fundus photographs and other examination data will be transmitted from the primary health care centre to the Oulu University Hospital via telecommunication networks. At the same time, more responsibility for the treatment and follow-up of patients will be shifted to primary health care centre physicians. As for *teleradiology*, the transmission of radiographs from primary health care centres and CT scans from hospitals to the Department of Radiology of the Oulu University Hospital will be studied. If necessary, the physician requesting consultation may ask, in addition to the radiologist's opinion, for the opinion of a surgeon, neurosurgeon or paediatrician. As for *telepsychiatry*, video conferencing is already being used in teaching, training, guidance and clinical work. The present project focuses especially on meetings for planning patient care. Provided the patient's consent is obtained, these are carried out between the primary health care centre of the patient's municipality and the Department of Psychiatry. As for *telepathology*, the study covers the transfer of micrographs of frozen sections from the Central Hospital of Mariehamn to Turku, as well as consultations between a pathologist in another central hospital with a pathologist at the Turku University Central Hospital.

The economic assessment of telemedicine has the following components: Cost analysis will include direct costs to the social welfare and health services and to the patient as well as indirect costs arising from treatments. Both the current and the telemedical procedure will be analysed. The expenditure associated with service transactions will also be investigated. The study of the effects will mainly concentrate on changes in diagnostic and treatment processes. Clinical change and follow-up of health-related quality of life will receive less emphasis, since telemedicine is expected to produce the same health effects as conventional methods. Nevertheless, telemedicine is expected to significantly improve the proficiency of the primary health care centre physician. The study also includes an investigation into the technical characteristics of the telemedical applications used. Physicians, nurses and patients will also be asked about their satisfaction with the method. Regarding study designs, randomisation will be preferred, but in many cases before/after comparisons will have to suffice. The assessment methods include cost-benefit and cost-effectiveness analyses. The data will be subjected to sensitivity analyses to determine the effects of changes in prices of equipment, manpower requirements, equipment specifications, etc., on the conclusions of the assessment.

1 INTRODUCTION

Telemedicine is one of the most important and fastest-evolving fields of medical technology. It employs telecommunication networks to transfer pictorial material, sound and text (e.g. radiographs, pathology freeze frames, fundus photographs and video footage). The networks can also be used to transfer other information related to the patient and his/her condition. Telemedicine is part of information and communication technology, and its utilisation requires reorganisation of work at operational, administrative and individual levels. Restructuring is the basis for efficient and effective operation and for deriving optimum benefits from telemedicine. For assessment of these new procedures, experiences of the function of the technologies have to be collected from both personnel and clients/patients (Building the European Information Society for Us All 1996).

Telemedicine and information technology open up new possibilities of distance services for health care personnel and clients/patients. The role of information technology is emphasised when the technology is used for altering structures and activities (Suomi Tietoyhteiskunnaksi 1995). The applications of information technology support health care by creating an infrastructure that is conducive to efficient and effective modern team work. Information technology also allows some health care functions to be carried out in patients' homes as well as a more efficient provision of special services (Rouvinen et al. 1995). The National Plan for Social and Health Services in 1997—2000 (Helsinki, 2 September 1996) states: "Regional and local data networks can be used to promote cooperation among different services. This requires the development of new models of operation in local government. Data networks can contribute to improved availability of the more specialised components of service chains at all service outlets of the area." Here telemedical applications can draw heavily upon the telecommunication infrastructure.

The implementation of telemedicine requires assessment of advantages, disadvantages, costs (especially transaction costs), investment schedules, fluency of communication, changes in work processes, as well as the process and division of work. According to the Strategy for the Utilisation of Information Technology in Social and Health Care (STM 1995), the increased use of information technology in the service sector has brought operations closer to real-time and made them more comprehensive, extending the individual responsibilities. This has made it necessary to restructure organisations. Horizontal cooperation has already started within primary health care. In hospitals, information technology causes changes in the bases of operation and in organisational culture. The above memorandum of the Ministry of Social Affairs and Health emphasises training and points out that training should take place immediately prior to the implementation of new methods and applications. Continuous assessment is required to appreciate and respond to changes in the nature of work in the social and health care sectors.

Telemedicine as well as other information and communication technologies are considered important by both local governments and health care districts. The Health Care District of Northern Finland has made use of these technologies in formulating medium-term operational strategies (PPSHP 1995, 1996) and in drawing up municipal profiles for specialised health care. Telemedicine is expected to play a role in the uninterrupted clinical management pathways that are being planned and set up by specialised health care units and municipalities.

The present project of telemedicine assessment is based on the development of and research in telemedicine carried out, on the one hand, by FinOHTA on behalf of the National Research and Development Centre for Welfare and Health (Kajander & Konttinen 1996, Kvist 1996) and, on the other hand, by the Health Care District of Northern Finland (Reponen et al. 1996, Mielonen et al. 1996, Haukipuro 1996). The municipalities of northern Finland have been active in setting up regional data networks and purchasing telemedicine-related equipment. The Oulu University Hospital and the municipalities using its services constitute a good object for evaluating telemedicine. In telepathology, the Pathology Unit of the Turku University Central Hospital and its partners are also a favourable and natural object of study.

FinOHTA has provided valuable assistance regarding telemedicine (Kalevi Lauslahti and Risto Roine) as well as health economics and assessment methodology (Pekka Rissanen and Harri Sintonen) during the preparation of the present report.

2 TELEMEDICINE

2.1 General

Telemedicine is defined as the examination, observation and treatment of patients and the training of personnel by utilising telecommunications so that expert assistance and patient records can be obtained at the right location regardless of the current whereabouts of the patient or the records (van Goor & Christensen 1992). Preston et al. (1992) define telemedicine more broadly, as any application of telecommunications to medicine. Both these definitions also incorporate medical distance training in its various forms (Wootton 1996, Harrison et al. 1996). Wootton (1996) sees telemedicine primarily as a process, rather than a technology. Such an operational process-oriented approach is common even to other information and communication technologies (Building the European Information Society for Us All 1996).

Distance consultation has been used in health care almost as long as the telephone (House 1991). In Sweden, electrocardiograms were already transferred by telephone at the beginning of this century (Olsson S, personal communication). The development in telemedicine was first led by the United States, owing to its space technology. In Australia and Canada, telemedical communication between primary and specialised health care units as well as among different medical establishments has been developed at the grass-roots since the 1950s (Dohrman 1991, House & Roberts 1977, House 1991). In Canada, Max House and his group used an extensive array of techniques from ordinary phone consultation to transmission of EEG and ECG tracings; in Australia, technologies such as radio communications were used (House 1990). The Canadian experience was subsequently availed of, for instance, within the health care services in Africa (House et al. 1987). Video conferencing was probably first used in telepsychiatry in 1959, when Cecil Wattson, a hospital psychiatrist of the University of Nebraska, provided individual and group therapy to hospital patients by means of an interactive television system (Graham 1996, Preston et al. 1992, Benschotter et al. 1965). Teleradiological transfer of X-ray images was first reported in 1959 (Jutra 1959).

2.2 Telemedicine in other countries

In Europe, telemedicine is particularly advanced in Norway where the research centre of the Norwegian Telecom and the University Hospital of Tromsø initiated an extensive development programme in the early 1990s (Nymo et al. 1993). A region with long distances, northern Norway has an Institute of Telemedicine at the University Hospital of Tromsø. In Sweden, specific projects devoted to teleradiology have been carried out (Olsson 1993). Among Central European countries, France has several projects underway (Lareng & Savoldelli 1994).

The most long-lived telemedical applications have been those fulfilling a practical need and using sufficiently advanced and cost-efficient technology. Expensive satellite technology is not available to all, although the U.S. armed forces, for instance, use it to provide specialised medical services to troops practically anywhere in the world (Mun 1993, Satava 1996). The examples of Canada and Australia show that even a basic technology can produce good results. On the other hand, developments such as the increase in computer performance have enabled teleradiological communication between primary health care centres (Reponen et al. 1995).

2.3 Telemedicine in Finland

The first experiment in teleradiology in Finland was carried out in 1969 when radiographs were transmitted between Helsinki and Oulu via the television network of the Finnish Broadcasting Company (Soila 1970). Indeed, radiology is the speciality that has most readily adopted the new means of communication in Finland. In 1996, image transfer facilities were in use at all five university hospitals, at seven central hospitals and at four regional hospitals. Only three primary health care centres used teleradiological communication, partly experimentally. All central hospital districts were planning to have regional communication systems in place within five years. In the private sector, a total of seven establishments had teleradiological facilities in 1996 (Reponen 1996).

Experimentation in telepsychiatry in Finland was started at the Department of Psychiatry of the Oulu University Hospital in 1995 (Mielonen et al. 1996). In addition to clinical work, its use has increased in medicine in general as well as in teaching and post-experience training in health care. Telepathology has been under development since 1992 and distance consultation in dermatology since 1995 (Helle & Helin 1996, Suhonen 1996). Isolated experiments have also been carried out on real-time transmission of gastroscopic images, and new areas of application are emerging, for instance, in surgery, ophthalmology and clinical neurophysiology (Kirkinen et al. 1990, Lehtola & Reponen 1996, Haukipuro 1996, Loula 1996). In teaching, video conferencing is becoming increasingly common, and institutions such as schools of nursing have been active in acquiring equipment for this purpose (Kvist 1996). A survey conducted by FinOHTA in 1996 found about 40 on-going experiments or projects (Kvist 1996). The most extensive account of the Finnish experience is to be found in the feature issue on telemedicine of the Finnish Medical Journal (17/1996).

2.4 Objects of telemedicine

The coming of age of telemedicine has instigated public health care to include telemedicine in its strategic plans. For example, in 1995 the Health Care District of Northern Finland set itself the following goals for telemedical services: (1) use of information technology (distance consultation, interorganisational data transfer) to strengthen the position of primary care in the system of services; (2) creation of an integrated system of distribution of health care services (access to best expertise at any time, correct staggering of care, cooperation, cost-efficiency); (3) qualitative improvement of communications and information production (real-time operation, reliability, speed, user friendliness, compatibility, confidentiality); and (4) creation of an adequate infrastructure (sufficient resources, reliability, availability) (Pohjois-Pohjanmaan sairaanhoitopiiri 1995). Similar strategic planning has been undertaken in other health care districts, e.g. in the Health Care Districts of Southwestern Finland, Satakunta and North Karelia.

The objectives of telemedicine can be roughly divided as follows:

- to reduce direct and indirect costs (loss of production or income) to the health care sector and patients
- to enhance citizens' equality in the availability of specialised medical services by bringing these services to remote primary health care centres
- to improve cooperation between specialised care and primary health care centres by moving services and expertise closer to citizens
- to promote the proficiency of physicians and other health care personnel by means of teleconsultation and video conference-based training
- to provide at least the same level of clinical care to patients as provided by conventional technology
- to reduce the waiting lists in specialised health care, e.g. for glaucoma and retinopathy screening and follow-up, and for initial and follow-up visits in surgery
- to improve and expedite consultations among different units of specialised health care in acute special cases (e.g. subspecialities in radiology and pathology, and neurosurgery).

In other words, there are great expectations for the future of telemedicine. Telemedical projects are considered to benefit all parties: local authorities (cheaper specialised services), hospitals, primary health care centres (improved service, increased supply of top expertise), patients (changes in state of health and quality of life, savings in costs and time), health care personnel (increased proficiency), employers (reduced absenteeism from work) and the social insurance system (reduced reimbursements).

3 ASSESSMENT OF TELEMEDICINE

3.1 The practice of health technology assessment

Health technologies have been assessed since the early 1970s (Warner & Luce 1982). The 1980s saw a substantial increase of activity in this field and increased cooperation between researchers. The International Society of Technology Assessment in Health Care (ISTAHC) was founded in 1985. It publishes a journal with the same title specialising in health technology assessment. In recent years, national units for technology assessment have been set up in many countries, e.g. FinOHTA in Finland.

The general purpose of health technology assessment is to produce information about the effectiveness, efficiency (cost-effectiveness) and risks of these technologies, and about the ethical and social aspects of their use. A new method or a current one may be assessed. Assessments investigate factors related to the adoption and diffusion of technologies either by producing new information or by reorganising and synthesising existing information. Assessments also provide health technology developers and manufacturers with information about commercial aspects and market structures worldwide.

Technology assessments aim at identifying the best approach among the various alternatives. They also try to define rules of decision-making to enable the desired goal (e.g. goals related to state of health, improvement of quality, fluency of business activities, speed of communication, diminished transaction) to be reached at minimum risk and cost. The economic success of health care operations depends on the efficiency of production and the fairness and equality of the distribution of services. Although efficiency is often emphasised in health care assessments, attention should also be paid to the distribution of the services (Wagstaff 1991). "Efficiency" should be construed broadly in this context. It also covers the social aspects of the application of a technology, such as customer-perceived accessibility and acceptability of the services.

Technology assessment has an increasingly important role in the allocation of health care resources. A new technology has to be proved to be superior (e.g. cost/QALY ratio; QALY = quality-adjusted life-year) to conventional methods before it can be recommended for wider use. Still, major new technologies have been introduced during recent decades without adequate assessment. Good examples of such technologies are the new imaging methods, e.g. computerised tomography and magnetic resonance imaging. Although they were soon found medically valid, their economically justifiable uses were not identified until they had been adopted extensively worldwide. Also, instrumentation based on high-technology is difficult to assess since the properties and prices of such items are in continuous flux. It would therefore be appropriate that assessment reports present sensitivity analyses concerning foreseeable technological advances and changes in prices.

3.2 Characteristics of telemedicine

The soaring demand for telemedical equipment has put great pressure on technology assessment, as decision-makers need up-to-date information about the appropriate uses of such equipment within the health service. The equipment is by now so advanced that it can be scientifically evaluated. Cost-benefit and cost-effectiveness analyses are not worth while if done on prototypes that differ considerably from models designed for serial production. The activities of purchasers and suppliers of telemedical services (the health care process) must also correspond to normal activities in their units; otherwise the effects and costs of the services cannot be reliably estimated. With the equipment and data networks used in Finland being topnotch, it seems justified to undertake technology assessments in Finland.

Telemedicine involves an operational change. The present project is aimed at producing data on the optimum timing of investments against the background of medium-term structural development in social welfare and health services, with emphasis on telemedicine, distance health care and home-delivered services. Technological change has specific implications for economic research on social welfare and health services. Operations constitute a value chain whereby a service, concept or product has value only if a specific demand exists. The recruitment of mental resources for adaptable and innovative advancement of welfare is the criterion of effectiveness. Organisational effectiveness is measured by the momentum of the service system, businesses and research institutions in the regional, national and international cooperation networks. Effects should be assessed on the basis of the functionality (changes in processes), fluency (savings in time, speed of diagnosis, speed of treatment) and efficiency (cost-effectiveness) of each telemedical project. The impact of the new activity on cost structures and people's quality of life should be estimated (Koivukangas & Valtonen 1995).

3.3 Assessment of telemedicine in the context of the health care process

The assessment is targeted at the health care process (clinical management pathway) where especially the flow of information and the price of time are analysed. It is important to assess how the new technology will change the work processes in health care. The health care process has four parts: determination of the patient's condition, planning of treatment, administration of treatment and follow-up. Determination of the patient's condition may be further divided into diagnostic investigations and diagnosis (Yura & Walsh 1988, 171). Telemedicine is primarily connected with diagnostic investigations, diagnosis and also the planning of treatment. Telepsychiatry can also be part of therapy. Corresponding phases can be discerned in the work of health care personnel. The research problem is: how does telemedicine affect these processes?

3.4 Estimation of the costs of telemedicine

Telemedical projects are aimed at reducing the expenditure related to the transaction of the specialised medical services produced by the central hospital. Alternatively, either information must travel, e.g. radiographs from Kuusamo to Oulu, or the patient/specialist must travel to Oulu/Kuusamo. The user fees of telecommunication networks in Finland are low by international comparison and, therefore, the transfer of information via networks is a relatively insignificant cost item. For example, a one-line ISDN connection from Oulu to Kuusamo costs about USD 1.20 per hour and a three-line connection USD 3.6 per hour (good-quality video conferencing link). More important from the point of view of telemedicine are the purchase and maintenance costs of equipment, the useful life of the equipment (5—7 years), and personnel expenses (salaries and training). Today (in 1997) good basic equipment for video conferencing can be obtained for less than USD 20 000.

The transaction cost theory presented by Williamson (1985, 1986) is based on the idea that all transactions (exchange-related operations) are arranged with a view to minimising transaction costs. This refers to any expenditure, starting with the production of the goods or service and extending to its delivery to the customer (end user). Services may be produced, for instance, by setting up a production network (health care district, municipality, business enterprises) where each unit of the network concentrates on those tasks in which it holds a comparative or acquired advantage. This allows the overall logic of the operations to be appreciated and the specific expertise of each unit to be effectively manifested. At the same time, the central unit of the network (e.g. Oulu University Hospital) is able to produce services for the maintenance, control and development of network-based operations (Neilimo 1994).

The costs of telemedicine at the primary health care centre are crucially dependent on the degree of utilisation of the equipment. For instance, if the primary health care centre is able to use video conferencing for many types of consultations, the share of the purchase cost of the equipment (fixed costs) in the total costs will be considerably reduced. Since the costs of telecommunication services are low, the main cost item at the primary health care centre will be staff salaries. In principle, a high degree of equipment utilisation (e.g. links with several primary health care centres or a large number of applications) at a hospital offering telemedical services should also reduce the costs of telemedicine. Much depends, however, on the number of personnel required to produce the service and on the time used for telecommunication.

The implementation of telemedicine is partly aimed at ensuring that health care services be produced at an optimum location from the viewpoint of both patients and financiers. Thus, visits to hospital outpatient clinics would be unnecessary when the treatment can be provided at the primary health care centre. Telemedical projects have a bearing on the areal distribution of specialised health care. This requires that geographical distances and the unique characteristics of the Finnish health care system (e.g. the primary health care centre network) be taken into account both in the planning of projects and in their assessment. However, long distances are not a prerequisite for using telemedical applications; on the contrary, they can be used even over short distances, such as within one hospital or in the same town among different units of health care (Wootton 1996, Fery-Lemonnier et al. 1996, Dossier CEDIT 1996).

3.5 Previous assessments of telemedicine

As the development of telemedical applications is in many cases still underway, their cost-effectiveness has not yet been thoroughly analysed. So far, two Norwegian articles on the cost-effectiveness of teleradiology have appeared in cited medical journals (Halvorsen & Sønbø Kristiansen 1996, Bergmo 1996). Furthermore, one French study on teleneurology has been published (Fery-Lemonnier et al. 1996, Dossier CEDIT 1996).

The first of the Norwegian studies, based on patient series from 1993, used a model of cost minimisation to simulate a situation where the minor plain X-ray facility of a small primary health care centre was replaced with a much more extensive service including some specialised examinations (Halvorsen & Sønbø Kristiansen 1996). In this alternative, the instrumentation of the radiology unit would have been modernised, new staff would have been hired, and radiology reports would have been obtained telematically. Potential health effects were not taken into account. The study concluded that, at less than 2000 patients a year, a teleradiology system offering an extensive range of examinations was more expensive than the current limited range of examinations in combination with a radiologist's visits from 140 km away. The teleradiological arrangement was also more expensive than having all examinations done at a central hospital. An equal distribution of services was considered to have been the main factor in favour of restructuring of operations (Halvorsen & Sønbø Kristiansen 1996). This study has been criticised for attributing to teleradiology even other costs than those directly caused by producing the alternative service. Furthermore, the study is theoretical and not based on clinical experience. The model described in the study is unsuited to Finnish conditions. It is true, however, that the dividing line between the costs of telemedicine proper and those related to a reorganisation of the whole operational model is still somewhat vague. A critical appraisal of this issue can be found e.g. in the article by Sund et al. (1996).

In the second Norwegian study by Bergmo (1996), using data from 1995, the cost effects of teleradiology were assessed on the basis of data derived from an actual clinical setting where the visits of a consulting radiologist were replaced with telematic transfer of images for analysis by a radiologist. During the period 1992—1995, an annual average of 8000 images were thus analysed. In the cost calculation, investments were considered to comprise the equipment and connections acquired for operating the teleradiology service; other hardware outlay by the department was not taken into account. The range of examinations was not changed in conjunction with the introduction of teleradiology. The study found teleradiology more economical than a radiologist's visits if there are more than 1576 patients a year and the hospitals are 160 km apart (Bergmo 1996).

The change in the approach and the difference in patient numbers had a significant effect on the result. The material of this latter study is probably the largest clinical teleradiology material reported in the world. Although this study is closer to Finnish circumstances, its general applicability is nonetheless rather poor since in Finland primary health care centre physicians analyse most radiographs themselves and only consult a radiologist in doubtful cases, whereas in Norway X-ray images are predominantly analysed by a radiologist.

CEDIT, the assessment unit of Parisian hospitals, conducted a two-stage assessment of teleneuroradiology. The first stage of the assessment in 1992, when teleradiology was not yet in use, consisted of a three-month follow-up of the operation of seven hospitals belonging to a neurosurgical emergency duty pool. Subsequently, 17 hospitals acquired commercial teleradiology equipment based on video image-capturing devices and film scanners. In 1995, another three-month follow-up study was conducted, targeting on the economic effects of the system. Effects on the results of treatment were not investigated (Fery-Lemonnier et al. 1996, Dossier CEDIT 1996).

On the basis of the first stage of the study, an estimated 10 000 telephone consultations were annually made by duty units in Paris and adjacent areas. These resulted in an estimated 6000 patient transfers. Of these transfers, however, 65% were estimated to result in the patient being sent back. In 57% of cases the neurosurgeon would have advised against transporting the patient if CT scans would have been available. The second stage of the study indicated that the transmission of images significantly reduced the number of unnecessary patient transfers. When the images were transmitted beforehand, and the decision to transfer a patient was based on them, only 18% of patients were sent back. The study population remained small during the follow-up, however, as images were transmitted only on 25% of patients (91 image transmissions, 44 patient transfers, 37 hospital admissions). As many as 14% of the image transmissions failed because of equipment, network or other disturbances. Furthermore, the quality of film scanner-produced images was not up to requirements, and the users' command of the features of the system was inadequate. The annual capital expenditure of the experimental system was 2 million francs and its operating costs 530 000 francs. Network costs, however, were only 5600 francs. The investigators estimated that 200 unnecessary patient transfers, corresponding to an outlay of about 400 000 francs, would be saved each year. The final conclusion was that the system tested would not have brought financial savings in patient transportation. Nevertheless, savings might be possible if the system were extended to all referring hospitals in the vicinity of Paris (Fery-Lemonnier et al. 1996, Dossier CEDIT 1996).

The assessment indicated, among other things, that a narrow-scope application did not bring savings in spite of a high patient flow. The main reason for the lack of economy was that the technology used was still too expensive, poorly developed and unstardardised. Today, equipment conforming to the DICOM (Digital Imaging and Communication in Medicine) standard can be used to implement a corresponding service at a fraction of the cost of the Parisian system. The assessment also indicated that the training of staff in the new technology is vital for success.

The Finnish Medical Journal published in 1996 a feature issue on telemedicine (Haukipuro 1996, Mielonen et al. 1996, Reponen 1996). The articles described the current situation of telemedicine in the specialities of surgery, psychiatry and radiology and reviewed the most important reports on telemedicine in these fields. Apart from the above studies, no economic assessments in these fields were known to exist at the time of writing of the feature issue, nor have any been encountered since.

National surveys on the use of telemedicine in health care have been carried out, for instance, in the USA (Hassol 1996), Finland (Kvist 1996) and Australia (Crowe 1993). For teleneurology, an extensive EU-funded methodological-empirical research project (TASTE) is currently underway. It addresses technology assessment on the basis of the cost-benefit analysis of the teleneuromedicine project in Paris (Dossier CEDIT 1996). An EU-funded joint project, VATAM, is also developing criteria for the assessment of telematic applications in medicine.

4 ASSESSMENT MODEL

4.1 Cost-benefit and cost-effectiveness analyses

Economic assessments of health care technologies are needed to produce information for decision-making concerning the allocation of public resources. Meagre resources may prevent society from optimising the welfare effects of its decisions. Should the health care market operate "perfectly", no cost-benefit or cost-effectiveness analyses would be needed since the market would be self-optimising. This is not the case in reality, however, because health care services are often influenced by external factors, and both competition and information are imperfect in the health care market. Health care assessment is one way of estimating these market-related problems. It also provides decision-makers with more reliable information about the relevant technologies than would be obtainable through simple surveillance of the market (Rissanen 1996).

There are four main methods of economic technology assessment: cost analysis, cost-benefit analysis, cost-effectiveness analysis and cost-utility analysis. The principle of cost measurement is the same in all these methods (Drummond 1990). Regarding health effects, cost-benefit analysis values health outcomes in monetary terms, whereas cost-effectiveness analysis and its subtype, cost-utility analysis, measure health effects in non-monetary terms. The latter may comprise natural units, such as attained life-years, or units based on preferences of the population, as in the QALY index. For assessment, at least two alternative health care technologies should be in use. Assessment then provides decision-makers with rules on which technology society should invest in and when.

The measures of effectiveness employed in cost-effectiveness analysis are usually expressed in clinical units such as attained life-years or reduction in mortality or morbidity. Effectiveness analysis may also make use of such structured measures of health or quality of life as have not been valued according to people's preferences (Koivukangas et al. 1995, Aalto et al. 1995, Rissanen 1996). Cost-utility analysis always monitors health effects with a valued single-index measure in a longitudinal study design. There are at present two valued and validated measures of health-related quality of life (HRQOL) in use in Finland that are applicable to cost-utility analysis.

These are the 15D developed by Harri Sintonen (1994 a, b) and the joint European EuroQol measure (Brooks, with the EuroQol Group 1996, Ohinmaa et al. 1996, Ohinmaa & Sintonen 1996). Results obtained using cost-benefit analysis or cost-utility analysis are, in principle, comparable even across different studies (and health problems). In practice, however, such comparisons are riddled with problems (Ohinmaa & Sintonen 1997, Johansson 1995).

Technology assessment involves as accurate cost analyses as possible of both the old and the new method. Cost analysis has three stages: (1) identification of all major cost items; (2) measurement of cost items in natural units; and (3) valuation of costs (Luce & Elixhauser 1990, Drummond 1990, Rissanen 1996). Cost analysis is aimed at obtaining a calculation of the accurate real societal costs of a technological application. The main cost categories in the economic assessment of operations are transaction costs and alternative costs.

Costs are divided into three general classes: direct, indirect and intangible costs. Costs, estimated as cost flows, are affected by the technology used, the functionality of the health care process, and the changes in the care provided. Direct costs charged to the patient include travelling costs and the cost of arranging home help. Direct costs charged to the health care service are those directly due to the application of telemedicine, e.g. equipment, labour inputs, use of other resources, and general expenditure (i.a. administrative costs). Direct costs are divided into fixed costs (e.g. equipment, salaries of permanent staff) and variable costs (e.g. supplies and drugs). This division is considered important in assessing quantitative changes in services.

From whose viewpoint should costs be examined? Usually costs accrued to each party in the project will be investigated (producer of the health service, patient, patient's family, other services, the rest of society). There is also some inclination to limit the study to costs borne by the health care service since the fundamental question is whether or not indirect costs affect health policy. The discussion is centred around how to cope with decreased earnings (losses in productivity). Some are of the opinion that they should be excluded from the agenda altogether (Gerard & Mooney 1993). Others consider that they should be included in so far as they can be accurately calculated (Koopmanschap 1994, Koopmanschap et al. 1995).

According to Ferguson and Keen (1996), information and communication technology has a profound impact on the modern health care system; this impact should be evaluated at the level of the entire system. The present assessment model uses an approach emphasising transaction costs as a frame of reference in evaluating the relationship between information and communication technology and the efficiency of services. This approach also serves to direct national and local investment, for instance in telemedicine, and to create databases and standards that might be applicable to strategies prepared by the Ministry of Social Affairs and Health (STM 1996).

There are studies indicating that new methods tend to renew the structure of services, but there is little information about their effects on outcomes of patient care (Anderson et al. 1994). Glandon and Buck (1994) showed that economic assessments of information and communication technology have yielded very little information about the real costs and benefits of investments. Telemedicine also contributes to integrated communication systems that allow information to be disseminated to greater numbers of health care professionals.

The core of transaction costs lies in imperfect information. Insufficient or imperfect information increases costs. No doubt transaction costs can be reduced by means of information and communication technology but the important questions are: what is the optimum level of investment and who is to pay for it? At issue are external effects which are positively influenced by fluent communication (Ferguson & Keen 1996).

Cost-effectiveness analysis in the present assessment model is based on the principle of a fixed budget (Birch & Donaldson 1987). It needs to be estimated how the extent of operations (health care districts, municipalities) has been proportioned in relation to the existing cost structures and whether it is possible to produce more care outputs without increasing unit costs. They should rather be reduced; in other words, it should be assessed whether the size of the service provider might yield economies of scale. In addition, the marginal costs (change in costs per change in output) and average costs of the outputs should be estimated.

4.2 Brief descriptions of projects to be assessed

The health care technologies to be assessed have to be sufficiently advanced to yield a reliable picture of their practicality. In the present model, therefore, the service concepts to be assessed were formulated according to generally used modes of operation.

The testing of the model will involve four specialities (telesurgery, teleophthalmology, telepsychiatry and teleradiology) from the Health Care District of Northern Finland and telepathology from the Health Care District of Southwestern Finland. Each of these will be subjected to cost-benefit and cost-effectiveness analyses on the basis of uniform assessment criteria. The latter is appropriate since some of the participating primary health care centres are involved through more than one speciality. The different projects will even collect same types of data on many other factors (e.g. travel costs, assessment of equipment and technology, and worker and patient satisfaction) (Table 1). The five subprojects in telemedicine will be briefly described below.

4.2.1 Telesurgery (Oulu University Hospital)

The aim is to investigate the efficiency of initial and follow-up visits in surgery utilising video conferencing between the Primary Health Care Centre of Pyhäjärvi and the Outpatient Clinic for Surgery at the Oulu University Hospital. To keep the study design simple, this study will admit almost exclusively orthopaedic patients.

The chief medical officer of the primary health care centre will examine all initial non-emergency referrals and select among them orthopaedic patients suitable for video conferencing. The selected patients will then be randomised into two groups: the study group who will have video consultation and the control group who will actually visit the outpatient clinic. The members of the study group will immediately receive an appointment for video consultation from the primary health care centre, whereas the referrals of the controls will be forwarded to the Outpatient Clinic for Surgery.

Patients invited for a follow-up visit to an orthopaedic surgeon will be randomised in the same way as those going for a first visit. Those randomised to video consultation will be given an appointment for video consultation, and those randomised into the control group will receive a follow-up appointment at the Outpatient Clinic for Surgery at the Oulu University Central Hospital, following the usual procedure.

Radiographs for video consultations will be transmitted analogously using a document camera. The radiographs will accompany the patient to the place of treatment. The assessment will also monitor the total number of referrals and follow-up visits in the speciality of surgery, originating from the Primary Health Care Centre of Pyhäjärvi. The patient's consent will be needed for video consultation.

4.2.2 Teleophthalmology (Oulu University Hospital)

This subproject will compare a telemedical application with conventional care for two diseases, glaucoma and diabetic retinopathy.

According to current practice, glaucoma patients first visit the Department of Ophthalmology of the Oulu University Hospital for fundus photography and visual field examination and a second time to see an ophthalmologist. Such a procedure, however, leaves the primary health care centre physician in the dark concerning the effect of the eye disease on the patient's overall condition.

In the experimental project, a primary health care centre physician will measure the glaucoma patient's visual acuity and intraocular pressure (gonioscopy as required), and a medical attendant will photograph the fundi and examine the visual fields. The primary health care centre physician will then have a video conference with an ophthalmologist based at the Department of Ophthalmology of the Oulu University Hospital, who will assess the need for (additional) therapy and outline the patient's treatment and follow-up for one year ahead. The patient's own physician at the primary health care centre will write/renew any drug prescriptions, taking into account any systemic diseases and concomitant medications of the patient, and will check that the patient's home care is being attended to, for instance, by relatives or through home-delivered services. The patient will be referred to the Oulu University Hospital only if the illness cannot be kept under control and interventions such as laser therapy or surgery are required, or if the specialist considers the diagnosis uncertain because of, for instance, the inadequate quality of the fundus photograph, thus requiring special examinations or procedures at the Department of Ophthalmology.

The current procedure for diabetic patients is such that the patient either has follow-up examinations at the Ophthalmology Outpatient Clinic of the Oulu University Hospital or undergoes fundus photography with a fundus camera ambulating among the primary health care centres. The film is sent to the Photography Laboratory of the Oulu University Hospital for processing whereafter the prints are examined by an ophthalmologist. Problems of the system include staff resources required by the processing of photographs, the variability of the procedure among different primary health care centres and the limited possibility of the primary health care centre physician to monitor this phase of the patient's management.

In the alternative teleophthalmological follow-up, a medical attendant will photograph the patient's fundi, and a primary health care centre physician will screen the abnormal findings. Using direct video communication, a specialist and the primary health care centre physician will go through all abnormal findings together and plan further management. The video contact will function not only as an important consultation link but also as an efficient training channel whereby the ophthalmological skills of the primary care physician are improved with increasing experience.

4.2.3 Teleradiology (Oulu University Hospital)

Teleradiology, the most advanced and most widely practised telemedical application in the world, refers to transmission of radiological images from one health care unit to another for analysis (Carey et al. 1989, Dohrman 1991, Sund 1993). A common investigational method, radiology has a bearing on patient care in almost all clinical disciplines (i.a. general practice, surgery, neurosurgery, internal medicine, paediatrics, otology). Teleradiological connections can be used in communication either among the different levels of health care (primary care - hospital, hospital - central hospital) or within one level (second opinion).

The present assessment project will primarily study the arrangement of radiological services at the Primary Health Care Centre of Kuusamo whereby telematics can be used for urgent cases. Primary health care centre physicians will be entitled to have images that have been obtained in Kuusamo transferred to the Oulu University Hospital for analysis by a specialist. The radiologist's report will be requested either immediately or within 24 hours, depending on the situation. The study will yield information about whether the specialist's reports change the original diagnoses and treatment decisions and what effect the system has on patient transfers to the central hospital 220 km away. Without teleradiology, it has previously been impossible to obtain a radiologist's opinion in urgent cases. It will also be investigated whether teleradiology influences the quality of radiology at the primary health care centre. Another object of investigation is the usability of the equipment and communications. The study will also compare the primary health care centre's current practice of radiograph analysis with the teleradiology service. In addition, arrangements will be made to enable clinical consultation on the basis of radiographs during the study.

The second object of study are consultations about emergency CT scans sent from central hospitals in northern Finland. A neuroradiologist's and/or neurosurgeon's opinion and instructions for management are obtained if necessary. The study focuses on the effects of such distance consultation on diagnostics, therapeutic decisions and patient transfers.

4.2.4 Telepsychiatry (Oulu University Hospital)

Telepsychiatry is defined as interactive psychiatric communication using a telecommunication network whereby two or more parties communicate simultaneously using sound and image (Mielonen et al. 1996).

The assessment will be initiated with a preliminary study on meetings for planning patient care and on other corresponding video conferences relating to the care of psychiatric patients receiving hospital treatment in Oulu. The video conferences will be conducted with the patient's consent among members of the therapeutic team, the patient's family and members of the local area network in primary health care centres participating in the project. As an alternative to video conferencing, the patient's family and/or network members will have to travel from the patient's home municipality to Oulu. The project will involve the Primary Health Care Centres of Kuusamo, Pudasjärvi, Taivalkoski and Pyhäjärvi.

The suitability of video conferencing for planning patient care will be surveyed by a written questionnaire. Tentatively, the following questions will be used:

1. How do the remoteness of the patient's home municipality, travel costs and the agenda of the meeting affect the form of meetings held for planning patient care?
2. How do video conference-based meetings for planning patient care affect patients' therapeutic outcome during hospital treatment?
3. How did the conventional meetings for planning patient care and the video conferences differ in setup?
4. Do different types psychiatric patients differ in their preferences between video conferencing and conventional meetings for planning patient care?

Meetings for planning patient care have been found to be therapeutically significant (Isohanni et al. 1996, Mielonen et al. 1996) but they are not used in the treatment of every patient. Meetings for planning patient care have been little studied as a form of support and as a routine procedure, so they may have practical significance for the health care process. After the preliminary study, corresponding data will probably be collected on conventional meetings for planning patient care, and this data will be compared with those on video conferencing. Meetings for planning patient care are an important element of the health care process in relation to the individual patient.

4.2.5 Telepathology (Turku University Central Hospital)

The Health Care District of Southwestern Finland participates in the survey with a subproject on telepathology including two objects of study:

1. The Central Hospital of Mariehamn in the Åland Islands is sending digital video images of frozen sections of tumours to the Pathology Unit of the Turku University Central Hospital. In this way, information about the characteristics of a tumour is obtained early during the surgical operation. Previously, no pathology service was available in Mariehamn and, therefore, all tumours suspected of malignancy had to be operated as if malignant. Telediagnostics on frozen sections now allow

conservative surgery to be performed whenever a tumour is found to be benign. The study will compare this practice with the previous one and the surgeon's preliminary diagnosis with the one made by the pathologist on the basis of frozen section images.
2. Costs and effects will be compared between digital transmission of pathology images and conventional means of forwarding (mailing of sections) between the Turku University Central Hospital and the Central Hospital of Satakunta. Video images (and freeze frames) have the advantage of allowing both the referring pathologist and the consultant pathologist to see the same section simultaneously, whereby the referring pathologist will immediately receive an opinion on structures of interest as well as an explanation of how the specialist in Turku reached his/her diagnosis. Telepathology also permits provision of systematic distance training from Turku.

4.3 Description of the assessment model

4.3.1 General description of the model

Several lists have been drawn up of factors to be considered in health technology assessment (e.g. Guidelines for Economic Evaluation of Pharmaceuticals 1994). Such lists are recommendatory by nature, and investigators should be provided with the necessary methodological alternatives for their implementation. In using the guidelines, investigators are able to choose those elements that are relevant to their subject of study and also measurable. So far, such lists have not been produced to any great extent in Finland.

For the present assessment of telemedicine, a recommendatory list was prepared on the basis of the general literature on health technology assessment (Drummond et al. 1987, Warner & Luce 1982, Drummond 1990, Luce & Elixhauser 1990). The leading principle was that it should be possible in each subproject to compare the telematic procedure with the older method of care. Table 1 summarises the relevant elements of each subproject. The letter x indicates the factors to be assessed in each study. The final results will indicate whether the new method is more efficient than the previous and under what premises. The measurements will make use of cost-benefit or cost-effectiveness analyses (sensitivity analyses).

Although the list of variables in Table 1 has been compiled especially for use in the assessment of telemedicine, it can be adapted with minor changes to other health technology assessments. If the method to be assessed is already extensively used, its technical properties, for instance, may not have to be studied. Even measurements of personnel satisfaction are often unnecessary. In the following, the main items in Table 1 will be discussed from the aspect of telemedicine assessment.

Table 1. The main variables and methods in projects of assessment of telematic technologies.

VARIABLES (Comparison of old vs. new method)	Tele-ophthalmology	Telesurgery	Teleradiology		Telepsychiatry	Telepathology	
			CH	PHCC		CH	M
COSTS:							
+ sender's investment costs	x	x	x	x	x	x	x
+ recipient's investment costs	x	x	x	x	x	x	x
+ sender's line costs	x	x	x	x	x	x	x
+ recipient's line costs	x	x	x	x	x	x	x
+ sender's salary expenditure: physicians, nurses, others	x	x	x	x	x	x	x
+ recipient's salary expenditure: physicians, nurses, others	x	x	x	x	x	x	x
+ sender's other costs (premises, administration, electricity, heating, etc.)	x	x	x	x	x	x	x
+ recipient's other costs (premises, administration, electricity, heating, etc.)	x	x	x	x	x	x	x
+ patient's (escort's) travel costs (by means of transportation)	x	x	x	x	x		x
+ physician's/nurse's travel (incl. journeys, allowances and loss in working hours)	x	x	(x)	x	x		
+ patient's/escort's loss in working hours	x	x	x	x	x		
+ patient's loss in leisure hours	x	x	x	x	x		
EFFECTS:							
+ improved diagnosis	(x)	x	x	x	(x)	x	x
+ monitoring of clinical change	x	x		(x)			
+ change in HRQOL		x	x	(x)	x	(x)	
+ change in health care process	x	x	x	x	x	x	x
+ improvement in proficiency at PHCC (CH)	x	x	x	x	x	x	(x)
TECHNICAL PROPERTIES:							
+ quality of image and sound	x	x	x	x	x	x	x
+ reliability and other properties	x	x	x	x	x	x	x
SATISFACTION/QUALITY:							
+ physicians	x	x	x	x	x	x	x
+ nurses	x	x	x	x	x	x	x
+ other staff (authorities)	(x)	(x)	x	(x)	x	(x)	(x)
+ patients	x	x		(x)	x		
+ patient's family / other concerned persons					x		
STUDY DESIGN:							
+ randomisation		x	(x)	x	x	(x)	
+ before/after comparison							
- at PHCC level	x	x	x			(x)	(x)
- at individual level	x	x		x	x		
+ control PHCCs		x	x	x	x		
ASSESSMENT METHOD:							
+ cost-benefit analysis (cost minimisation analysis)	x	x	x	x	x	x	x
+ cost-effectiveness analysis	x	x	x	(x)	x	x	
SENSITIVITY ANALYSIS:							
+ by remoteness of PHCC	x	x	x	x	x		x
+ by patient flow of PHCC	x	x	x	x	x	(x)	x
+ by useful life of investments	x	x	x	x	x	x	x
+ by type of investment; lines	x	(x)	x	x	(x)	x	(x)
+ assessment of degree of advancement	x	x	x	x	x	x	x

CH = central hospital
PHCC = primary health care centre
M = local hospital (Mariehamn)
HRQOL = health-related quality of life

4.3.2 Estimation of costs

Table 1 presents an itemisation of costs by subproject. Costs will be estimated using a questionnaire containing some questions that are universal and some that are specific to each subproject. The form will query, for instance, the time a person spends on different tasks and associated travel costs. Standardisation of the forms will save on time spent in designing each form as well as yield comparable results on the costs of the various subprojects. Changes in the operational process and their effects on costs will be investigated with separate forms or interviews. Cost functions will be derived in much the same way as in the Norwegian telemedicine project (Bergmo 1996). Although costs will be valued using, as far as possible, the true costs, shadow prices will be used in some cases (see Rissanen 1996, Mishan 1988).

Loss in production will be estimated empirically on the basis of the average loss in working hours which, in turn, will be valued according to the mean hourly wage. These calculations will be done both for patients and their escorts (Table 1). The cost of arranging domestic help will also be taken into account. Loss in leisure hours will be estimated on a time basis without monetary valuation. In conformity with the treatise of Rissanen (1996), the present assessment will not include indirect costs in the basic calculation. Such an approach would unduly separate younger (employed) persons from older (retired) ones. This choice is realistic since, for instance, the teleophthalmology project mainly involves older people. As indirect costs can be substantial in telemedical projects (e.g. teleophthalmology and telesurgery), the results of the cost analysis will also be expressed including indirect costs. This will allow observation of the sensitivity effect of the results of cost-benefit and cost-effectiveness analyses on the bases of cost calculation.

Some of the transaction costs can be calculated by comparing current and new operational settings (telepsychiatry, teleradiology, teleophthalmology) with respect to a particular technology, division of labour and level of demand. In the present study, transaction costs will be estimated by comparisons of costs of the health care process (e.g. the effect on care of faster flow of information) and by observation of changes in administrative costs.

4.3.3 Assessment of other effects

It is a major goal in almost all of the subprojects in telemedicine to acquire more accurate, specialist-made diagnoses (Table 1). Telepsychiatry is the only speciality focusing not on diagnosis but on the supply to different parties of information concerning the patient and his/her care and, thereby, on improved care. The projects in surgery, radiology and pathology will investigate improvements in the accuracy of diagnoses with study designs where the original, e.g. primary health care centre physician-made, diagnosis is compared with that made by a specialist. The number of cases where the diagnosis is rendered more accurate or slightly or significantly altered will also be investigated. In addition, the percent share of cases where teleconsultation has had a significant effect on therapy will be estimated.

For teleophthalmology - though the equipment can also be used for diagnosis - the present study will concentrate on *monitoring clinical change* in patients with glaucoma or retinopathy. If untoward changes are observed, the patient's therapy will be reviewed in cooperation with the primary health care centre physician. In telesurgery, some of the video conferences will be follow-up visits where the main research problem will be whether clinical change is detectable by video consultation. In teleradiology, clinical change will be examined from telematically transmitted radiographs and by comparing old and new images. The project also comprises elements that may have direct health effects. These include telediagnosis or teleconsultation on urgent cases. For instance, a neurosurgeon on duty may give therapeutic advice in cases of intracranial haemorrhage (whether to operate or not) on the basis of CT scans transmitted teleradiologically from the central hospitals of entire northern Finland. Without such rapid X-ray image-based consultation these patient face the hazard of over- or undertreatment.

Changes in *health-related quality of life* can only be monitored in some of the substudies (Table 1). As a rule, teleconsultation would be expected to provide at least as good therapeutic results as does conventional care. Nevertheless, changes in quality of life are possible in cases where the accuracy of the diagnosis can be significantly improved and there is also a change in therapy compared with the original treatment plan. In telepsychiatry, meetings for planning patient care constitute a part of the actual therapy and, therefore, an increase in the use of meetings for planning patient care, brought about by video conferencing, can improve the patient's quality of life in the long term. For ophthalmology, the aim is not to study quality of life, as retinal changes are so slow that the patient may not even be aware of a gradual deterioration of vision. As for pathology, changes in patient management are expected in the area of frozen section diagnostics, which may have an impact on both the patient's state of health and quality of life.

Telematic services are assumed to influence *the health care process itself* (see Wootton 1996). In ophthalmology, the new technology will allow the primary health care centre physician to participate more actively in the treatment of the glaucoma patient. It will also provide the primary health care centre physician with specialist skills required in the rest of the patient's management. Changes in the health care process and increases in proficiency at the primary health care centre will be important items of study even in the other subprojects. In telesurgery, the primary health care centre physician may perform clinical examinations under the guidance of a specialist as well as observe even other diagnostic procedures of the specialist. Video consultation may initially increase the demand for surgical services but with increasing skills of the physicians the number of video conferences should decrease for the most common cases (e.g. in orthopaedics). Most subprojects will also assess video conferencing as a learning tool.

Teleradiology is a new computer-assisted work method where the remote site and the unit supplying the service form an entity. Mastery of this entity is very important for the quality of work, but very little research related to this topic has been carried out in the health care sector. Mastery of the new method and creation of a shared work space is crucial to the quality of the service (Karasti et al. 1996). The functionality of cooperation in teleworking will be studied together with the Research Group on

Computer-Supported Cooperative Work (CSCW) of the University of Oulu (Department of Information Processing Science).

Teleradiology can significantly reduce waiting times in non-urgent cases which would otherwise have to wait until a consulting radiologist visits the primary health care centre. In pathology, the patient's management can be brought closer to his/her home and, especially in the case of nonmalignant tumours, the patient can be treated in his/her home area. Teleradiology, telepathology and teleophthalmology can also be used to provide important services related to the monitoring of the quality of care.

In psychiatry, meetings for planning patient care can at present be offered only to about half the patients, although the arrangement of such meetings is considered an important part of therapy. This is partly due to the long distances between the individual participants. If video conferencing can succeed in linking the patient's family and the authorities of his/her home municipality more intimately to the therapeutic process, this should also have an influence on the outpatient therapy following hospital stay.

4.3.4 Assessment of the technology applied

Since telemedicine uses novel devices, the assessment should include an evaluation of the technical properties of the equipment. In teleophthalmology, teleradiology and telepathology, the images must have sufficient resolution to preclude erroneous interpretations due to poor image quality. Many studies have been carried out in teleradiology on the diagnostic accuracy of transmitted images (Reponen et al. 1995, Reponen et al. 1994). In pathology, a preliminary study will have to be conducted on the diagnostic quality of frozen section images transmitted from Mariehamn and the Central Hospital of Satakunta. The experiment can make use of old specimens and, thus, quickly demonstrate the diagnostic reliability of the method. In teleophthalmology, the freeze frame is actually the video still picture which will not change in resolution during transmission. Video still pictures are already being used locally in diagnostic microscopy, so their quality is reliable.

A successful video conference is highly dependent on faultless transmitted image and sound. The present study will draw upon the Department of Psychiatry's extensive knowledge and research concerning the implementation of video conferencing. All participants of the project will evaluate the quality of image and sound in a separate questionnaire survey. In addition, staff will be asked to assess the functional reliability of the equipment and to identify any problems in the equipment or communication links. Good technical properties of telemedical systems are prerequisite to their extensive adoption in Finland.

4.3.5 User satisfaction / quality

Users' satisfaction with the facilities is particularly important when adopting new alternative technologies while a functional older method still exists. A staff that is dissatisfied with the equipment will not use it. Satisfaction is related to the technical properties of equipment and, therefore, these will be enquired on the same questionnaire. The satisfaction of patients (and the patients' families) with the new method will only be queried in cases where the patient is involved in the event of producing the service (ophthalmology, surgery and psychiatry). Further, it should be noted that patients' satisfaction with telematic services is also influenced by ancillary operations, such as the integration of doctor's appointments, X-ray examinations and blood tests with the telemedical services.

4.3.6 Study design

The study material can be randomised in almost all subprojects; randomisation will be most comprehensive in telesurgery. For radiology, randomisation of non-urgent cases can be performed by randomly allocating patients who have already been telematically examined to re-examination by a visiting radiologist. This will indicate whether the old system would have led to a health care process different from that undertaken on the basis of telematic findings.

Before/after comparisons within a single primary health care centre will be carried out mainly in ophthalmology and radiology. In ophthalmology, before/after comparisons are justified since the patients invited for follow-up visits in fact comprise the total study population of their area; also, the order of the patients is practically random. This population will be divided in two, so that the old method will be applied to the first subset for six months, and then the new method will be used with the second subset. Preliminary studies showed no systematic factors that could affect the subsets. In teleradiology between hospitals and between primary health care centres and hospitals (in urgent cases), comparisons will also be made within each institution between the situation before and after the intervention.

Although both initial and follow-up visits will be randomised in the study on telesurgery, it is still sensible to compare the results of video conferencing with the recent results of distance outpatient clinics at the same primary health care centre (and in neighbouring municipalities). Client-related before/after comparisons will be made in four subprojects (Table 1). Control populations will be used in surgery, radiology and psychiatry (in municipalities without video equipment).

The technologies will be assessed in two phases. First, the costs of the new and old methods as well as their effects on the health care process will be estimated using costs minimisation/cost-benefit analysis. This is intended to quickly answer the question whether it is economically wise for the local authorities, central hospitals and other units of specialised care to invest in all or just some of the telematic services under study. Preliminary results on most of the subprojects should be available by August—September 1997.

The second phase will comprise, in addition to detailed cost-benefit analyses, qualitative investigations of the technologies used. This phase will also contain cost-effectiveness analyses in which even measures of health-related quality of life may be employed. For most subprojects, these assessments will not take place until 1998. The final reports on the subprojects and possibly a joint article will also be prepared then. As Table 1 shows, both cost-benefit and cost-effectiveness analyses can be done in almost all subprojects. In many instances, however, effectiveness will have to be measured using variables related to the patient's clinical condition or to a change in diagnosis instead of health-related quality of life.

4.3.7 Sensitivity analyses

Much of the practical interpretation of the results revolves around sensitivity analysis in which cost and outcome factors are simulated under various basic assumptions (see Johannesson et al. 1997, Halvorsen & Sønbø Kristiansen 1996). In this way, future developments can be accounted for. Sensitivity analyses will be done by location of primary health care centre, number of patients, useful life of investments (e.g. 5—7 years) and type (price) of investments. Since telemedicine evolves very rapidly, the results will also reflect the effects of this rapid development upon investment decisions. Sensitivity analysis can provide recommendations for the timing of municipal procurement of certain telematic services.

5 IMPLEMENTATION AND SCHEDULE OF THE STUDY

The presented study of application of the assessment model will be carried out during 1997 and 1998. It is important for the success of the study that the variables mentioned in Table 1 can be measured as well as possible. The subproject-specific questionnaires for patients, physicians and nurses will be prepared in January 1997, after which data collection will be initiated. In preparing the forms, comparisons among the subprojects as well as the possibility of combining data will be taken into account by using the same questions across subproject boundaries whenever possible. The staff forms will also survey the effects of telemedicine on health care processes/concepts.

Preliminary results from the study can be expected in summer 1997. By then it will be known how well video conferencing is technically adapted to surgical consultations and, in psychiatry, to meetings for planning patient care and, also, how satisfied the participants of video conferences are with this facility. Costs will be analysed during the summer and early autumn to obtain basic figures on the economy of telemedically produced services at primary health care centres and central hospitals. The plan is to publish results from these analyses at a telemedicine seminar to be held in Oulu in autumn 1997. The preliminary findings of the cost analyses will be published as soon as possible to provide decision-makers with a basis for decisions on the procurement of telemedical equipment.

Data collection will end in late 1997, after which the final cost-benefit and cost-effectiveness analyses will be carried out. The first subproject-specific reports based on the full data will be published in the spring of 1998. The findings of the study will also be compiled in a joint report including results from all subprojects. The joint report will be compiled during 1998. The completed study will also indicate how well the present assessment model works in practice. Apart from reports in scientific journals, the findings will be presented in the FinOHTA newsletter.

6 APPLICATION OF THE FINDINGS

The findings of the study will have great practical significance to local governments, people, central hospitals, health care districts and other public corporations. The findings can be used to give recommendations on the preconditions for starting telemedical operations within a certain speciality in a particular locality. The study has the advantage of taking into account the price level and the characteristics of the health care system in Finland. As the subjects of study have a relevance to major public-health problems, substantial societal benefits are expected from the findings.

Since the new care arrangements are in the process of becoming a permanent feature, the greatest future changes in factors affecting decision-making can be assumed to be related to investment and operating expenditures. In this context, the findings of the study can be used to calculate the effects of different investment and operation alternatives under the assumption that investment costs will fall e.g. by 30% over the next two years. The costs of operating the equipment may also decrease considerably, for instance, if communication between various locations can be effected without auxiliary staff in the health care process or in a section of it (e.g. a camera operator in video conferencing).

The sensitivity analyses of the study will account for the effect on decision-making of some degree of technological change. This will be especially pertinent in cases where the assessment has come up with poor reliability of operation for a telemedical appliance. If improved technology can substitute previous, inadequate telemedical examination or therapeutic procedures, the effects of such technological development on the results of cost-benefit and cost-effectiveness analyses can be calculated in advance. Changes in the quality of diagnostics and in the speed of information transfer can also be anticipated using sensitivity analyses.

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FinOHTA

Finnish **O**ffice for **H**ealth Care **T**echnology **A**ssessment

Goal:

• to promote effectiveness and efficacy in Finnish health care

Modes of operation:

• collection, analysis and synthesis of information about national and international health care technology assessment studies and its dissemination to health care users

• provision of quantitative and qualitative support to national assessment studies

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