Economic impact of remote specialist consultations using videoconferencing: an economic model based on data from randomised controlled trials

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Abstract – **The University Hospital of North Norway plans to replace some of the outpatient consultations with real-time telemedicine. It has been estimated that 7000 consultations annually can be handled remotely by videoconferencing. As part of this initiative, a project assessing the economic impact of using videoconferencing at scale has been initiated. Cost-effectiveness will be assessed using models based on data from existing randomised controlled trials. A literature search in relevant databases has been conducted to collect data on patient flow and clinical effectiveness (QALYs). Data on the cost parameters will be collected locally. The data on costs and effectiveness parameters will then be synthesised to estimate average group values. Probabilistic methods will be used for estimation of expected outcomes and for sensitivity analysis. This paper describes the planned modelling evaluation, reports the results from the literature review and outlines potential model structures.**

Keywords – cost-effectiveness analysis, decision analytical modelling, telemedicine, videoconferencing, randomised trials, literature review, and economic model.

I. Introduction

Telemedicine has been around for almost two decades, but is still viewed as outside the mainstream of most health care services (except possibly for radiology) [1]. Implementing telemedicine technologies as part of routine health care delivery requires evidence of the following: its technical feasibility; its practicality in a clinical setting; and finally its being worthwhile, that is, that the additional costs are met with savings or improvements in health outcomes [2, 3]. Main arguments for introducing telemedicine services has been to decrease costs, improve efficiency and increase access in health care delivery. These cost savings and efficiency potentials make economic evaluation of central importance to telemedicine evaluations. To be able to make well-informed resource decisions, information on costs and consequences associated with these decisions must be available. Information on costs and consequences can broadly be collected in two ways: alongside trials and observational studies (primary data); and, from the existing literature (secondary data) [4, 5].

A. Economic data

New primary economic data can be collected alongside randomised clinical trials, non-randomised interventions and observational studies (general issues in economic evaluations are common to all these) [5].

Randomised trials are designed to investigate the relative effectiveness of different medical interventions [6]. The most important advantage of randomisation is that it minimises allocation bias and balances other factors that might affect the result, both known and unknown. Strictly controlled trials are not very common in telemedicine research for practical reasons, nor are they well suited for economic evaluations. The more controlled a trial is the less can be concluded about how much the intervention costs and how well it works for normal caseloads in everyday practice. The trial context is often very different from real-world decisions and conditions that will improve internal validity in randomised controlled trials will undermine the economic evaluation [7]. Real-setting clinical trials are in many telemedicine situations both time consuming, difficult to conduct (too few participants) and expensive to run. This often leaves decision-makers without information about clinical and economic consequences of different telemedicine interventions.

Another way to inform decision-makers is to use the best available evidence from existing sources and decision models. Secondary data can come from clinical trials, observational studies meta-analysis and case reports found in the literature. Data can also be found in databases and administrative records. Decision models provide a means to bringing this evidence together in a systematic way.

B. When to Model

A well-designed model is essentially a tool that can simulate or mimic a clinical trial [8]. Models can simulate different scenarios by making explicit assumptions about the incidence, prognosis, duration, benefits, health-related quality of life and costs. It allows one to investigate how cost and benefits might change if the values of key parameters in the model change. The purpose of modelling is not to make unconditional claims about the

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consequences of an intervention, but rather to reveal the relation between assumptions and outcomes [9].

Whether to use new trial-based data or existing data and decision models in economic evaluation of telemedicine should be seen in relation to the objective and role of the study and the viewpoint of those who are expected to use the results [7]. A randomised trial focuses on particular measurements for specific patients in one specific setting. These are essential in establishing safety and clinical effectiveness as a first stage in developing telemedicine applications. The evidence base for decision-making should be based on the best available measurements on clinical and economic outcomes and these come from trials. Decision models are useful in situations where more evidence is required than can be obtained in one single trial. Furthermore, in a situation where a decision has to be made in the absence of evidence from trials, modelling can help structure the problem, assess potential pathways and identify the level of uncertainty.

In this paper, we describe an economic evaluation based on existing data and modelling techniques. The paper is structured as follows: Section II provides the background and includes an overview of the local context, the use of clinical videoconferencing, and the rationale and aim of this project. Section III outlines the research approach and provides an overview of the modelling study and the data collection. Section IV reports the results of the literature search and propose two preliminary model structures. Section V discusses implications and limitations. Finally, conclusions and future work are discussed in Section VI.

II. BACKGROUND

The University Hospital of North Norway (UNN) plans to replace some of the outpatient consultations with real-time telemedicine consultations. In May 2011, the management at UNN made a decision to invest in videoconferencing equipment at scale to provide specialist services to patients at local health centres and GP-clinics in the region. A committee report from 2011 estimated that 7000 patient consultations annually could be handled by video-consultations saving both hospital visits and travel costs (unpublished but available from the author on request). The implementation has been postponed awaiting further investigation into conditions for and potential consequences of a large scale videoconferencing network.

The reason for the videoconferencing initiative seems to be twofold: First, it has been recognised that high quality services for patients cannot be provided by one health care discipline alone or by one single sector. The new health care reform; the Coordination Reform is one initiative to ensure high quality services across sectors and between health care levels [10]. Using videoconferencing can contribute to more personalised and integrated care pathways: it will give the patients the opportunity to get treatment locally; they might avoid burdensome travels; and this might improve the quality of care through a better coordinated health service delivery. Second, the management at UNN wants to reduce the costs by reducing hospitalisation and outpatient visits and save travel costs (the health authorities cover travel costs in Norway).

A. *Clinical videoconferencing*

The use of videoconferencing to examine and treat patients over a distance can be used in most medical specialities and settings [2, 11]. In a remote specialist consultation, the patient, usually accompanied by a health care worker, meets the specialist in real time via videoconferencing. These latter types of telemedicine consultations have for example been used in psychiatry [12-14], dermatology [15, 16], oncology [17], to support renal dialysis [18], cardiology [19], in diabetes, asthma, epilepsy [20, 21] and lifestyle group counselling [22]. There now exists a range of evidence supporting that videoconferencing for a variety of conditions produce similar health outcomes to treatment delivered in-person [11, 23, 24]. However, there exists no robust evidence that remote video consultations is cost-effective compared to conventional health care delivery. Wade (2010) reviewed the literature of real-time video-communication and found it to be cost-effective for home care and access to on-call hospital specialists, it showed mixed results for rural service delivery, and it was not cost-effective for local delivery of services between hospitals and primary care [25]. It is, however, not realistic to make one general recommendation for cost-effectiveness across services and settings. The local context will decide important cost parameters, such as travel costs, the need for investment in infrastructure and technologies, and the opportunity costs of health professionals making it difficult to compare results across evaluations. Most reviewers, however, report that the evidence of cost effectiveness is scarce and more research on resource allocation and costs is still needed [26, 27].

B. *Aim*

In this project, we will use a combination of existing evidence found in the peer-reviewed literature and local data to build a decision model to analyse the economic impact of remote specialist consultations. The model will be used to structure and simulate patient pathways with, and without videoconferencing; to identify expected outcomes of different strategies; and, to explore the costs and benefits of different scenarios under different assumptions. The main aim is to assess the cost-effectiveness of remote specialist consultations using videoconferencing compared with usual care. This work is conducted in three related phases:

1. Develop the structure of the cost-effectiveness model and identify key parameters relevant to the decision problem;
2. Identify local setting parameters such as medical field, investment and technical support costs, personnel- and travel costs.
3. Populate the cost-effectiveness model and analyse the economic impact of remote specialist consultations using videoconferencing in Northern Norway.

This paper describes the economic modelling study and reports on its first phase.

III. METHODS

Decision models provides a framework to draw costs and benefit data from a range of different sources together in a systematic way [5].

A. *The Modelling Study*

In this project, a decision model will be constructed to assess the cost-effectiveness of remote specialist consultations compared to usual care. In the model remote specialist consultation refers to situations in which the patients, usually accompanied by a health care worker at one location, consults with the specialist at the hospital using videoconferencing. Usual care refers to situations in which the patients see the specialist in a face-to-face consultation at the hospital. The model is populated with parameters collected from the peer-reviewed literature and with general cost parameters collected locally.

The primary outcome in the economic model is costs and quality adjusted life years (QALYs) in a cost per QALY ratio. If QALYs are not found in the literature, other effectiveness measures will be considered. If no effectiveness measure is found, episode of care (number of patients managed) will be used as an effectiveness measure and a net cost (or net benefit) per episode of care will be used as pathway outcome. Data on costs and effectiveness parameters are synthesised in a cost per unit of effect or a net costs to estimate average group values (cohort models). The model assesses short-term alternative branches or events defined as consultations. Another key model parameter of interest is the proportion of patients within each strategy or pathway. Probabilistic methods will be used both for estimation of expected outcomes and for sensitivity analysis. The evaluation will have a health provider perspective, that is, only include costs falling on the health care budget.

The data are collected in two steps. The first step is to conduct a systematic literature search to identify existing studies analysing effectiveness and cost-effectiveness of videoconferencing alongside randomised trials. The literature can provide information on structural assumption, parameter inputs, and areas of uncertainty. The second step is to collect local cost parameters. These include equipment costs, technical support costs, personnel costs, travel costs, and other health care costs from the health clinics involved. These will be collected from hospital departments, local health centres already using videoconferencing and regional health authorities.

This paper reports results from the first step: the literature search and structural model assumptions.

B. *The systematic review*

The systematic literature search has two main objectives; to collect information on a) previous cost-effectiveness analyses and decision modelling studies in real-time telemedicine studies; and, b) to collect data on structural assumptions, probabilities and clinical effectiveness in randomised controlled trials of using videoconferencing.

The search strategy included two main search terms:

1. Real-time telemedicine OR videoconferencing OR video-link OR video-communication OR videophones OR video-consultation OR hub and spoke OR remote teleconsultation OR real-time consultation AND
2. a) Economic modelling OR economic model OR decision model OR decision analytic model OR decision modelling OR cost-effectiveness OR cost-utility OR
   b) Randomised OR randomized

The following databases have been searched: PubMed, PsycINFO and ISI Web of Knowledge, CINAHL, Cost-Effectiveness Analysis Registry and the NHS Economic Evaluation Database (NHS-EED). Furthermore, reference lists in the retrieved articles and existing reviews have also been screened. Cost-Effectiveness Analysis Registry and the NHS Economic Evaluation Database (NHS-EED) were searched using videoconferencing, video-consultation or video-link as search words.

Only articles published in peer-reviewed journals were included. The search was limited to English language text and publication date from 1990 to 2013.

The articles relevant for this study cover remote specialist consultations using real-time audio and visual telemedicine technologies (videoconferencing) and only include aspects in which the patient is directly involved and present at the or GP office, local health centre or rural hospitals. Studies analysing video contact from home, store-and-forward transmissions of data, e-mail consultations or structured telephone support were excluded. We only included randomised trials to collect data on clinical process or patient flow through the health system, and clinical effectiveness of using videoconferencing.

Selection of relevant publications was based on information found in the abstracts. Full-text articles were retrieved when the abstract indicated a cost-effectiveness analysis and an assessment of effectiveness and patient flow through the health system. Full-text was also

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retrieved for closer inspection if the abstract did not provide clear indication of the content. Figure 1 shows a flow diagram mapping the number of studies identified, the number of studies included and excluded, and reasons for exclusions.

IV. RESULTS

The literature search identified 1265 records. These were found searching PubMed (n = 618), ISI Web of Knowledge (n = 532), CHINAL (n = 81) PsycINFO (n = 21) and NHS Economic Evaluation Database (NHS-EED) (n = 13). No articles were found searching the Cost-Effectiveness Analysis Registry. From these records, 46 full text articles were retrieved for further inspection. Two more articles were identified screening reference lists. Sixteen articles were selected for inclusion (see Figure 1).

The full text articles assessed were reviews, methodology papers, effectiveness and cost-effectiveness studies alongside randomised trials, case control studies and decision models. The decision modelling studies were analysing the use of videoconferencing in pulmonary care, stoke treatment and home visits for tuberculosis treatment [28-31].

A. *Inluded studies*

Sixteen articles were included in this review. Ten of these met all the inclusion criteria, that is, they reported results from randomised trails and included information on clinical process and patient flow of using videoconferencing in remote specialist consultations [32-41]. These articles form the basis for the model estimation in this study. Six other studies were also included. These were effectiveness or cost-effectiveness studies containing information on clinical process and effectiveness. These studies used case-crossover design [42-44], retrospective pre-post design [45] and two were models based on data from the literature [28, 46]. Reliable parameter data from these studies will also be used where parameter values are still lacking.

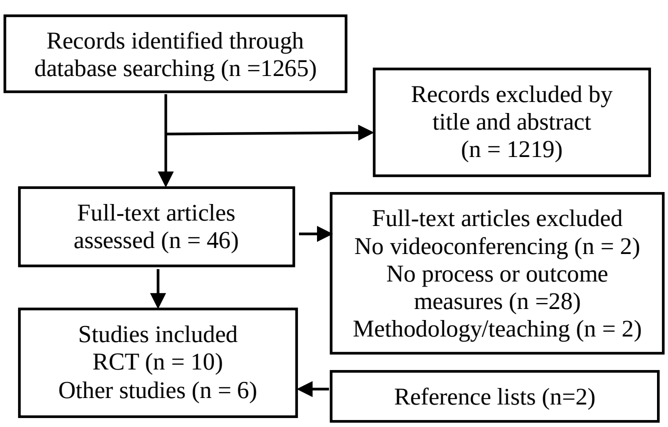

Figure 1. Flow diagram.

The included studies found data on the following parameters:

- The proportion of patients in which videoconferencing is a suitable and reliable option compared to face-to-face consultations.
- The proportion of patients in need of second consultation
- Outcome or clinical effectiveness
- Time use

B. *Model structure*

Data on patient management and patient flow found in the literature suggest that videoconferencing is acceptable for approximately 70 % of the patients [41, 42, 44]. This is supported by a review where it was reported that 70 % of the patients avoided travels [46].

Furthermore, the studies included reported an increased follow-up rate for patients seen by telemedicine [32, 34, 35]. For example one large scale telemedicine trial found that the follow-up visits for video consultations compared to usual care in general practice had an odds ratio of 1.52, 95% CI 1.27 to 1.82. [32].

The data suggest two possible models that describe the structural process of using video-consultations. The first model assumes a broad approach and includes all patients in the videoconferencing arm without any pre-selection. Figure 2, show this model populated with follow-up data from a large scale telemedicine trial by Wallace et al (2002) [32] as an example. Usual care refers to outpatient consultations. The second potential model assumes a screening process selecting the patients most suited for remote consultations beforehand. This might reduce the relative increase in follow-up visits for the remote arm. Figure 3 shows the model with pre-selection of patients.

Other parameters found in the included papers were:

- Effectiveness as number of patients managed times utility (preferences for videoconferencing compared to outpatient consultations). Utility was estimated by expert opinion (10 physicians) [28]
- Time use for the different alternatives [33]

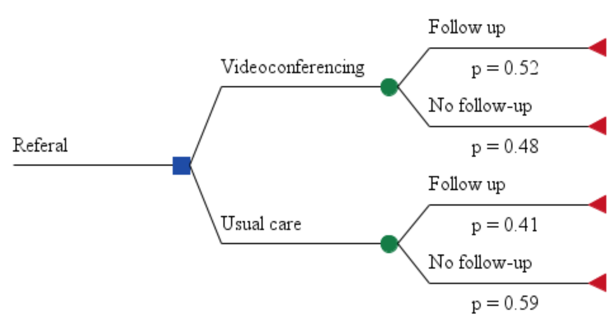

Figure 2. A decision model without pre-selection of patients populated with follow-up data from a large scale telemedicine trial as by Wallace et al (2002) [32] as an example.

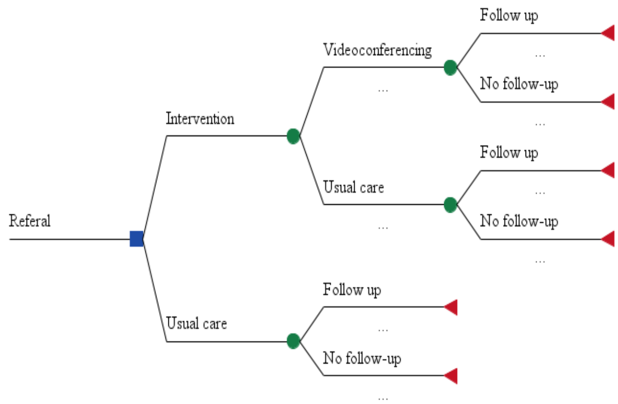

Figure 3. A model where the patients suited for videoconferencing has been pre-selected

None of the studies measured the clinical effectiveness of videoconferencing in QALYs.

V. DISCUSSION

The literature on telemedicine is extensive. A search in PubMed in November 2013 found over 16 000 papers on the topic. There is, however, a relatively small number of randomised trials in telemedicine research and even fewer analysing the effect of using videoconferencing in providing remote specialist consultations. A review from 2012 identified 141 randomised controlled trials in telemedicine [47]. These studies analysed interventions in chronic disease management and the majority analysed home monitoring and telephone support. Few studies looked into the use of videoconferencing. Recent telemedicine research seems to focus more on home based services using monitoring and telephone contact with less focus on remote specialist consultations using videoconferencing.

Only ten randomised trials met all the inclusion criteria and analysed the effect of remote specialist consultations. The clinical disciplines in the included articles were mental health, dermatology, orthopaedics, neurology and single studies with a mix of medical and surgical specialities. The studies varied in terms of sample size, outcome measures and contexts. All these studies included some evidence on patient management and the clinical process of using videoconferencing to examine and treat patients over a distance. Furthermore, we found that the increased offer of follow-up differed between specialities. It was highest in surgical specialities and neurology and lowest in mental health [32, 35, 38, 40]. This implies that the base model will have to include a specific patient group within one clinical discipline and not a general patient population.

We were not able to find any studies measuring clinical effectiveness in QALYs. One reason for this may be that using videoconferencing as a substitute for a face-to-face consultation have little or no effect on patient's health. The benefits for the patients are most likely the avoidance of burdensome travels. Since no QALYs were found, we will consider other preference measures identified from literature search. If the effectiveness measures is of low quality and cannot be used, a net cost per episode of care will represent the pathway outcome (assuming similar health outcomes).

The main purpose of this literature search was to identify randomised trials analysing the effect of remote specialist consultations. Consequently, the scope is therefore quite narrow. Furthermore, the fact that only articles written in English and published in peer-reviewed journals (to provide some basic quality control) were included is recognised as a limitation. The search strategy used might also have missed some evaluations. Remote specialist consultation is not easily defined. Some analysts might have used other terms and definitions to describe the provision of specialist treatment over a distance than the search terms used in this review.

The proposed model structures can be seen as hypothetical trial with two arms. In some context, the model might include a third arm in which the specialist travels to the remote health centres or clinics. None of the reviewed studies included this option. It will, however, be considered if a third arm is relevant in the areas selected for this study.

There is a number of valid concerns about using models to assess the economic consequences of an intervention [48]. The most important is the quality of the data used. The quality and validity of the results from modelling studies are not any better than the data used in the models. Telemedicine research has in general been criticised for being full of demonstration projects, anecdotal evidence and poor study design [49]. One way to ensure high quality data has been to limit the included studies to randomised trials. This strategy, however, produced few articles. To supplement the data six other studies were included.

VI. CONCLUSION AND FUTURE WORK

This paper has presented an economic modelling study, reported results from its first phase of collecting existing data from the literature and outlined potential model structures.

The next step is to develop the model, that is, to decide clinical field and primary care catchment area, to decide the final model structure and to organise and systematise the data on key input parameters and probabilities. Furthermore, we have to decide pathway outcome (cost per unit of effect or net costs). The model structure will also be adapted to local practices. Then local cost will be collect. The final step is to populate the model and analyse the cost-effectiveness of using videoconferencing for remote specialist consultations.

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