An Economic Model of Remote Specialist Consultations using Videoconferencing

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***Abstract* - Remote specialist consultations using videoconferencing have the potential to reduce costs and improve access to health care services. The University Hospital of North Norway now plans to replace some outpatient consultations with videoconferencing. As part of this initiative, a project assessing the use of models to analyse the economic impact of videoconferencing has been initiated. In this project, existing evidence found in the peer-reviewed literature and local cost data were used to build a model that illustrates the decision problem associated with investing in videoconferencing. This paper proposes a generic model that can be used as a template for more specific videoconferencing models. This work also presents a specific model illustrating the expected outcomes in the field of urology. Both of these models can be used to clarify the options under consideration, to assess potential costs and benefits, and to determine whether further analysis is need to enable informed decision making in the field. This paper also presents a threshold analysis and shows values for when a conclusion changes in favour of one of the options.**

Keywords – remote care; telemedicine; videoconferencing; randomised trial; literature review; economic modelling; cost-effectiveness analysis.

I. Introduction

The current paper provides an extended version of the work presented at The Sixth International Conference on eHealth, Telemedicine, and Social Medicine (eTELEMED) in 2014 [1].

Telemedicine has been around for almost two decades, but it is still viewed as outside of the mainstream of most health care services [2]. Implementing telemedicine technologies as part of routine health care delivery requires evidence of its technical feasibility, practicality in a clinical setting, and its being worthwhile (i.e., the additional costs are met with savings or improvements in health outcomes) [3, 4]. The main arguments for introducing telemedicine services have been to decrease costs, improve efficiency, and increase access to health care services. 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 be collected in two ways: alongside trials and observational studies (primary data), and from the existing literature (secondary data) [5].

A. Economic data

New primary economic data can be collected alongside randomised controlled trials, non-randomised interventions, and observational studies (issues in economic evaluations are common to all of 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 that 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]. Clinical trials in the real-world setting are in many telemedicine situations time consuming, difficult to conduct (too few participants), and expensive to run. These obstacles leave decision makers without information about the 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 of collating this evidence 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, quality of life and costs. A model 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 consequences of an intervention, but rather to reveal the relationship between assumptions and outcomes [9].

The decision of whether to use new trial-based data or existing data and decision models in an economic evaluation of telemedicine should be considered in relation to the study's objective and role and the perspective of those who are expected to use the results [7]. A randomised trial focuses on particular measurements for specific patients in a given setting. These trials are essential as a first stage in developing telemedicine applications by establishing safety and clinical effectiveness. The evidence base for decision making should be based on the best available measurements of 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 a single trial. When a decision has to be made without evidence from trials, modelling can help structure the problem, assess potential pathways, and identify the level of uncertainty. Such models are valued for their simplicity and transparency and can be an excellent way to clarify the options of interest [10].

In this paper, a combination of existing evidence found in the peer-reviewed literature and local cost data are used to build a model for the provision of specialist consultations through videoconferencing. The main aim is to build a general model that structures the decision problem and forms the basis for assessing economic consequences in more specific models. This paper is structured as follows: Section II describes the background including an overview of the local context, the use of clinical videoconferencing, and the rationale and aim of this project. Section III outlines the materials and methods including an overview of the modelling study, the literature review, and the model parameters. Section IV reports the results and proposes two models. Section V discusses implications and limitations. Conclusions and future work are discussed in Section VI.

II. Background

The University Hospital of North Norway (UNN) plans to replace some of its outpatient consultations with real-time telemedicine consultations. The UNN is the leading healthcare provider and health trust in the northernmost region in Norway. The UNN also serves as the local hospital for residents of Troms County and parts of Nordland, providing the full range of hospital functions (see Fig. 1). Troms County includes many isolated areas with long distances to the hospital. The county has a scattered population of 162,050 in an area of 26,000 square meters and consists of 24 municipalities.

In May 2011, the management at UNN decided to invest in videoconferencing equipment at scale to provide specialist services to patients at local health centres and general practice clinics in the region.

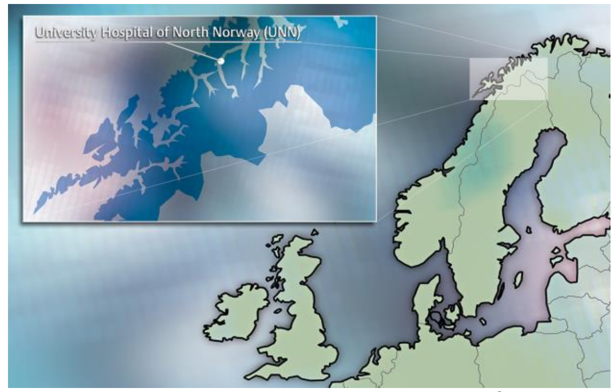

Figure 1. Troms County and the northern part of Nordland County (inserted).

A committee report from 2011 estimated that 7,000 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 is twofold: First, it has been recognised that high-quality services for patients cannot be provided by one health care discipline alone or by a single sector [11]. Using videoconferencing can contribute to more personalised and integrated care pathways: it will give patients the opportunity to obtain treatment locally, they might avoid burdensome travel, and this could improve the quality of care through better coordinated and integrated health service delivery. Second, the management at UNN wants to lower costs by reducing hospitalisation and outpatient visits and to save on travel costs (the health authorities cover travel costs in Norway).

A. *Clinical videoconferencing*

The use of videoconferencing to examine and treat patients from a distance can be used in most medical specialties and settings [3, 12]. In a remote specialist consultation, the patient, usually accompanied by a health care worker, meets the specialist in real time via videoconferencing. This type of telemedicine consultation has been used in psychiatry [13-15], dermatology [16, 17], oncology [18], cardiology [19], in diabetes, asthma, epilepsy [20, 21], to support renal dialysis [22], and for group counselling [23]. There is now a range of evidence demonstrating that videoconferencing for a variety of conditions produces similar health outcomes to treatment delivered in person [12, 24, 25]. However, there is no robust evidence that remote video consultations are cost effective compared to conventional health care delivery. Wade (2010) reviewed the literature on real-time video communication and found it to be cost effective for home care and access to on-call hospital specialists; whereas, for rural service delivery, video communication showed mixed results, and it was not cost effective for local delivery of services between hospitals and primary care [26]. It is not realistic to make one general recommendation for cost effectiveness across services and settings. The local context will determine important cost parameters, such as travel costs, the need for investment in infrastructure and technologies, and the opportunity costs of health professionals, all of which make 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 [27, 28].

B. *Aim*

In this project, a combination of existing evidence found in the peer-reviewed literature and local cost data are used to build a model of specialist consultation provided via videoconferencing. The model is used to structure and simulate patient pathways with and without videoconferencing, to identify the expected outcomes of different strategies, and to explore the costs and benefits of various scenarios under different assumptions. The main aim is to develop a general model that can be used as a template to assess the potential economic consequences of investing in videoconferencing in more specific models. This work consists of three related phases:

1. To develop the structure of the model and identify key parameters relevant to the decision problem;
2. To identify local setting parameters such as the medical field, investment and technical support costs, and personnel and travel costs;
3. To populate the model and analyse the economic impact of remote specialist consultations using videoconferencing in the hospital's catchment area.

This paper describes the economic modelling study, presents results, and discusses the rationale for using economic models to support health care managers in deciding whether to invest in videoconferencing or not.

III. Methods

The following section provides a description of the materials and methods used in this project. This section outlines the model framework, the design of and processes used in the literature review, the model probabilities found, and the local cost parameters used in the models. For more details on the systematic review see [1].

A. *Model overview*

This paper constructs an economic model to analyse the economic consequences of providing specialist consultations through videoconferencing. In the model, remote specialist consultation refers to situations in which the patient, 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 patient sees the specialist in a face-to-face consultation at the hospital.

The primary outcomes in the economic model are costs and effectiveness measured as episodes of care or number of patients managed. The measure of quality-adjusted life-years (QALYs) was initially planned as an outcome measure, but no existing studies have collected QALYs in randomised trials of videoconferencing. Therefore, a net cost (or net benefit) per episode of care (patient consultation) was used as a pathway outcome. The model assesses short-term alternative branches or events defined as consultations. One-way sensitivity analyses were conducted to assess the robustness of the results. Parameters have been varied one at the time to assess the effect of the model and to determine threshold values.

The model was populated with parameters collected from the peer-reviewed literature in combination with local cost data. The evaluation takes a health provider perspective, that is, only costs within the health care budget have been included; travel costs are included since these are covered in the health care budget in Norway.

The data was collected in two steps. The first step was to conduct a systematic literature search to identify existing studies analysing the effectiveness and cost-effectiveness of videoconferencing alongside randomised trials. The literature provided information on structural assumptions, parameter inputs, and areas of uncertainty. The second step was to collect local cost parameters including equipment costs, technical support costs, personnel costs, travel costs, and other health care costs from the health clinics involved.

The models were built and analysed using the software program TreeAge Pro 2015.

B. *Overview of the literature review*

A systematic literature search was conducted 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 from randomised controlled trials on the use of videoconferencing.

The following databases were searched: PubMed, PsycINFO and ISI Web of Knowledge, CINAHL, Cost-Effectiveness Analysis Registry, and the NHS Economic Evaluation Database (NHS-EED). Reference lists in the retrieved articles and existing reviews were also screened. The 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 texts and a publication date in the range of 1990 to 2013. A subsequent search was conducted to include papers from 2014. No additional studies were found.

The articles included in the review covered remote specialist consultations using real-time audio and visual telemedicine technologies (videoconferencing) and only included aspects in which the patients were directly involved and present at the general practice 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. To ensure the quality of the data on clinical process or patient flow through the health system and the clinical effectiveness of videoconferencing, only randomised trials were included.

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 randomised

Selection of relevant publications was based on information found in the abstracts. Full-text articles were retrieved when the abstract indicated that the article would include a cost-effectiveness analysis and an assessment of effectiveness and patient flow through the health system. The full text was retrieved for closer inspection if the abstract did not provide clear indication of the content.

The literature search identified 1265 records. These were found by 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 by searching the Cost-Effectiveness Analysis Registry. From these records, 46 full-text articles were retrieved for further inspection. Two more articles were identified by screening reference lists. See Bergmo (2014) for details [1].

The literature search found ten articles that met the inclusion criteria. These were randomised trials and included information on the structural assumptions, probabilities, and clinical effectiveness of using videoconferencing [29-38]. Six non-randomised studies were included. These analysed clinical effectiveness or cost-effectiveness and included information on the clinical process. These studies used case-crossover design [39-41] and retrospective pre-post design [42], and two of the studies presented models based on data from the literature [43, 44]. Reliable parameter data from these studies have also been used to support parameter values from the randomised trials. The studies included data on the following parameters:

- The proportion of patients for which videoconferencing is a suitable and reliable option compared to face-to-face consultations.
- The proportion of patients in need of a second consultation (follow-up).
- Time use for the different alternatives.

C. Model assumptions and probabilities

Data on patient management and patient flow found in the literature suggest that videoconferencing is acceptable for approximately 70% of patients [38, 40, 41]. This indicates that not all patients can be seen via video, suggesting that patients have been pre-selected or self-selected. Videoconferencing can be less suitable for patients with a hearing problem and patients with dementia or other communication barriers, for example. Some patients may need a physical examination, while others prefer to meet the specialist in person, which varies between medical specialities. Videoconferencing is more suitable in psychiatry than orthopaedics, for example [37, 40].

The studies reported a higher follow-up rate for patients utilizing telemedicine [29, 31, 32]. For example, one large 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. [29]. The difference in the follow-up rate also differs between specialties [29, 31, 32, 39], with less difference in dermatology [36].

None of the studies used QALYs to measure the clinical effectiveness of videoconferencing. Most studies took a cost per patient approach. Therefore, a net cost (or net benefit) per episode of care (patient consultation) was used as a pathway outcome in the present study.

The time health professionals spend to complete a video consultation and an outpatient consultation was assessed in Jacklin et al. (2003) [30]. These time measurements included the total time spent by the specialist and the general practitioner, who were both present during one video session. These time estimates were based on observations of a small sample of consultations [30]. Details on the model inputs are shown in Table I.

D. The local cost parameters

Only provider costs have been included in this modelling study. These include health care costs and travel costs. Regional health authorities cover all travel costs except for a small user fee.

The cost of a video consultation includes investment costs, technical support, the costs of using the network (line rental), and the time costs for the health providers. Investment costs have been collected from suppliers and from the IT and accounting departments at the hospital and local health clinics

In the current project, a health professional accompanies the patient during the videoconferencing session, which assumes that the clinics have invested in a standard standalone videoconferencing unit placed in a dedicated office or studio.

TABLE I. MODEL INPUTS

Definition	Value	Source
Proportion of patients seen		[38, 40, 45]
Videoconferencing	0.71 (0.64-0.75)	
Outpatient	1*	
Proportion of follow-up		[29, 31, 32, 36]
Videoconferencing	0.36 (0.26-0.52)	
Outpatient	0.29 (0.22-0.41)	
Professional time per consultation		[30]
Videoconferencing		
Local Physician	26 min (158 NOK§, €18.9)	SSB
Specialist	20 min (140 NOK§, €16.7)	
Outpatient		
Specialist	11.8 min (83 NOK§, €9.9)	
Costs per episode of care		Local costs
Videoconferencing		
VC units#	311 NOK (€37.2)	
Network rental	43 NOK (€5.2)	
Time costs	298 NOK (€35.7)	
Outpatient		
Specialist costs	83 NOK (€9.9)	
Travel cost	823 NOK (€98.5)	[46]

€1 = 8.41 Norwegian Kroner (NOK) 15 May 2015
* Assuming that all patients receive treatment if referred by GP
§ SSB Statistics Norway 2014 https://www.ssb.no
\# Includes equipment, installation, and annual support costs.
Total annual cost 85 850 NOK (assuming 3% discount rate and 5-year equipment lifetime).

This is the most commonly used equipment for video consultations and meetings in the region. The cost calculation is based on investing in videoconferencing equipment from Cisco TelePresence MX300 G2.

The total investment costs including equipment and installation costs were annuitized into an equivalent annual cost assuming a 3% discount rate and a 5-year lifespan for the equipment. The unit costs (i.e., cost per patient consultation) were calculated assuming six consultations a week for 46 weeks (276 patient consultations annually). This annual workload was estimated by a medical expert and is based on a videoconferencing service in the orthopaedic unit at the hospital.

The cost of an outpatient consultation at the hospital includes time costs for the specialist and travel costs for the patients. The average travel cost estimate for the region was found in Augestad et al. 2013 [46]. This estimate was calculated by dividing the total travel costs for the region by the total number of trips. Time costs for the medical professionals were estimated based on the national average for the monthly wage of specialists working at the hospitals and for locally employed physicians at health centres (see Table I for cost details). Overhead costs are not included because these are assumed to be small and to not affect the results. All costs are in Norwegian Kroner (NOK).

E. Other assumptions

The model includes a second consultation after the initial video consultation to account for the higher follow-up rate of videoconferencing. It has also been assumed that a small proportion of the second consultations in the videoconferencing option are outpatient consultations at the hospital.

IV. RESULTS

The data found in the literature suggest a model with two main options, one with videoconferencing and one without. This model assumes a screening process to select the patients suited for remote consultations beforehand. The studies also suggest that more patients will be scheduled for a follow-up consultation in the videoconferencing option compared to the outpatient option.

The model is shown in Fig. 2 and illustrates the different options that are present in the decision problem. The model calculations are based on the model specification, technical equipment, and local cost estimates described above (Section III, C and D). Whether or not to invest in videoconferencing based solely on cost effectiveness can be viewed as a decision problem with two options. The costs of the videoconferencing option will also include the costs of treating the patients when videoconferencing is not suitable (the branch labelled outpatient consultation in Fig. 2). The net costs will also depend on the different follow-up rates included in the model. This model shows that the 'invest in videoconferencing' option has the lowest net costs (see Fig. 2 for details).

This model includes average values, making it less useful for decision making in specific areas. However, a generic model can be used as a template for more specific models adapted to one defined clinical field in a particular local practice or health clinic. The model input can easily be altered to fit any setting in which the decision problem is whether to invest in videoconferencing or not.

Fig. 3 illustrates the use of the generic model adapted to the same decision problem in the clinical field of urology. In this model, the decision problem is whether to set up videoconferencing in the field of urology at a local health centre 67 km from the specialist hospital. In the literature, 46% of the urology patients in the telemedicine option were offered a follow-up consultation compared to 35% in the outpatient option [29]. In this context, the travel cost to the hospital was NOK 300, assuming that all patients travelled by bus.

Assuming similar patient workloads and costs as in the generic model, the least costly alternative in the field of urology is outpatient consultation at the hospital (see Fig. 3 for details).

The parameters most sensitive to the model results are the unit costs of the videoconferencing option, as either equipment prices or as the number of patient consultations (annual workload), and the distance from the local health centre to the specialist hospital.

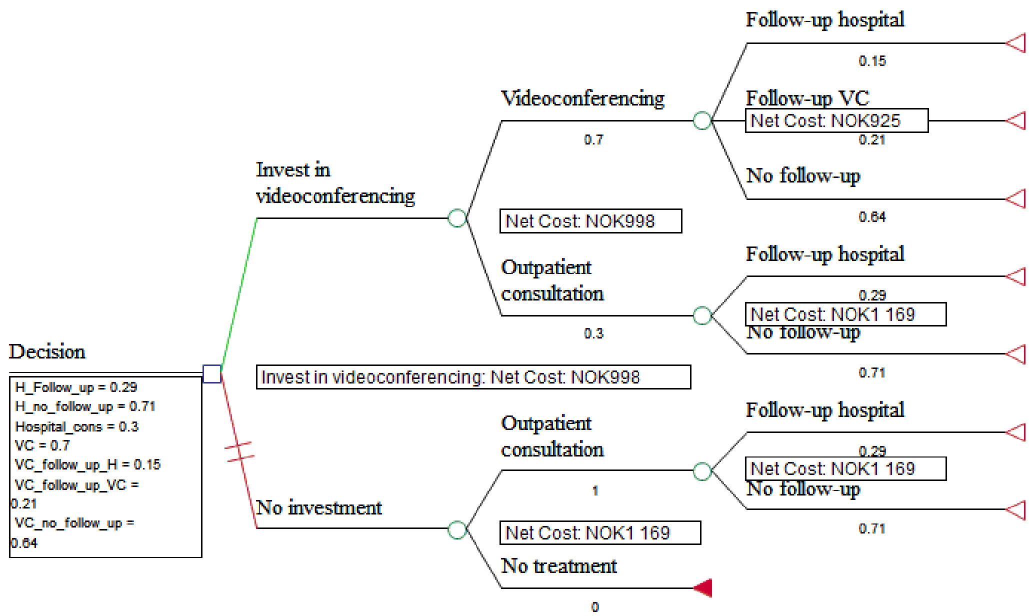

Figure 2. The videoconferencing model.

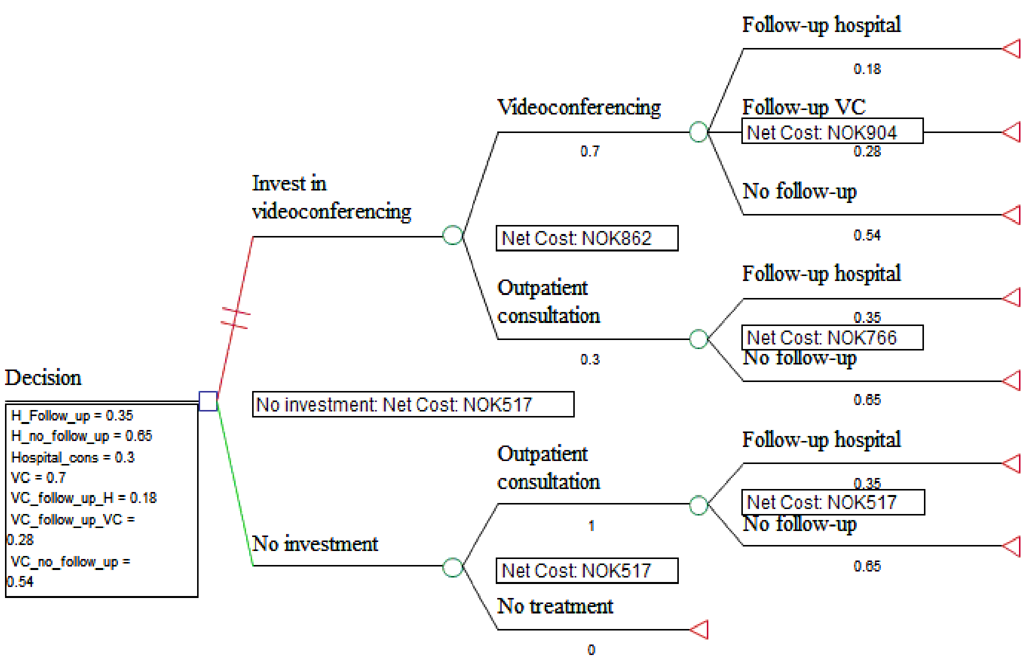

Figure 3. The model adapted to urology.

Halving the number of patient consultations in the videoconferencing option in the generic model (from six consultations each week to six consultations every two weeks), alters the results in favour of the 'no investment' option (model not shown). Another example is to analyse the use of video consultation in urology at a different location where the travel cost is twice the amount used in the urology model shown in Fig. 3. This changes the results and makes the 'invest in videoconferencing' the least costly option (model not shown).

One-way sensitivity analyses were conducted on the data in the generic model. The analyses show that for videoconferencing cost estimates above NOK 853 (e.g., a service with less than 167 video consultations per year or less than 4 per week), or for travel costs that equal less than 610 NOK per patient, the results change in favour of the 'no investment' alternative (see Figs. 4 and 5). The results are not sensitive to changes in the other model parameters.

V. DISCUSSION

This paper developed an economic model describing the decision problem associated with investing in videoconferencing to provide remote specialist consultations. The results show that the decision to invest in videoconferencing depends on more than the cost difference between the two modes of consultations. The total cost of investing in videoconferencing must also consider the costs of those patients who are not suited for videoconferencing and a higher follow-up rate for the patients who participated in videoconferencing.

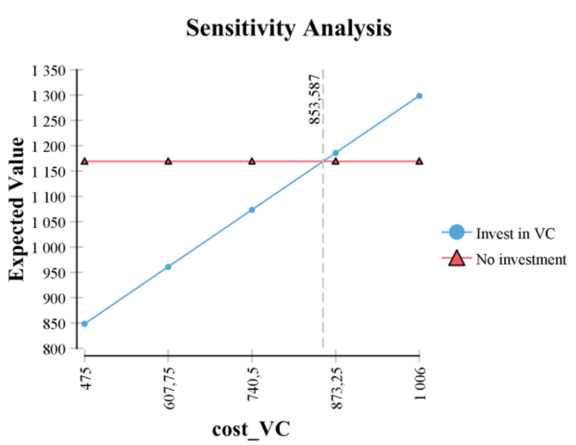

Figure 4. Sensitivity analysis showing the net costs (expected values) with different VC-cost estimates ranging from 475 NOK (3 patient consultations per week) to 1006 NOK (9 patient consultations per week) in total (from €56.9 to €120.4).

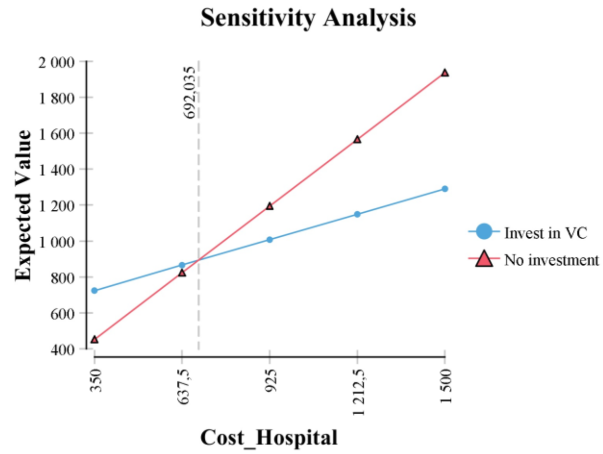

Figure 5. Sensitivity analysis showing the net unit costs (expected values) with different outpatient cost estimates ranging from 350 to 1500 NOK (€41.9 to €179.6).

This generic model is intended to be used as a template for more specific models that analyse the economic impact of providing specialist care to patients living in remote areas. The model can also be used as a framework for indicating whether a more detailed analysis is needed. Decision modelling is increasingly being used to assess the need for and value of additional research [10]. The generic model can also be further developed to include other technologies in a home-based setting, for example.

There are valid concerns about using models to assess the economic consequences of new interventions [47]. The most important concern 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 [48]. One way to ensure quality data in this study has been to limit the data sources to include only randomised trials.

The literature on telemedicine is extensive. A search in PubMed in March 2015 found over 18,000 papers on the topic. There are, however, a relatively small number of randomised trials in telemedicine research and even fewer analysing the effect of using videoconferencing. A review from 2012 identified 141 randomised controlled trials in telemedicine [49]. These studies analysed interventions in chronic disease management and the majority analysed home monitoring and telephone support. Few studies examined 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.

None of the studies found in the literature used QALYs to measure clinical effectiveness. One reason for this may be that videoconferencing is used as a substitute for a face-to-face consultation, and therefore has little or no effect on a patient's health. The benefit for the patients is most likely the avoidance of burdensome travel. However, QALYs have been used as outcome measures in monitoring and other home-based telehealth studies [50]. Because no QALYs were found, a net cost per episode of care was used as a pathway outcome (assuming similar health outcomes).

The main purpose of the literature search was to identify randomised trials that analysed the effect of remote specialist consultations. Consequently, the scope of the review study is narrow. Another limitation is that only articles written in English and published in peer-reviewed journals were included to provide some basic quality control. The search strategy used might have missed some evaluations, partly because the term remote specialist consultation is not easily defined. Some analysts might have used terms to describe the provision of specialist treatment from a distance that differed from the search terms used in this review.

The proposed model structure can be seen as a hypothetical trial with two arms. In some contexts, the model might include a third option in which the specialist travels to the remote health centres or clinics. None of the reviewed studies included this option, but the generic model can easily be adapted to include a third option.

Some of the model inputs were not available in the literature and have been estimated. A medical expert working with remote consultations in orthopaedics estimated the annual workload used to calculate the unit cost of videoconferencing. An expert also estimated the probability of additional follow-up after a video consultation as an outpatient referral. Using expert opinions to estimate model input is acknowledged as a limitation.

The costs included in the real-time telemedicine option were based on the purchase of standard standalone videoconferencing equipment. Leasing can be more suitable in some settings. Any change in equipment types and prices will influence the investment cost. For example, a desktop computer could be sufficient in some settings where only two persons (specialist and patient) are present in the consultation. The type of equipment that the clinics choose to purchase is one of the main cost drivers in the model. The choice of equipment will depend on what the specialist deems appropriate for the patients involved in the video sessions.

The assumed number of patient consultations per year used to calculate the annual costs is another uncertain parameter. A change in annual workload will alter the result, and if the equipment is used for multiple purposes, then the cost must be shared between all users. Sensitivity analysis can be used to illustrate different threshold values when a conclusion changes in favour of one of the options. This allows decision makers to determine whether videoconferencing is a potential cost effective solution in their designated area or whether a more detailed analysis of cost and benefits is needed.

The cost of outpatient consultations has been simplified to include only the costs of the health professionals involved and travel costs for the patients. Only costs assumed to differ between the alternatives and costs that have the potential to affect the outcomes have been included. More detailed cost estimates will increase the precision of the model and allow the calculation of more accurate potential cost savings.

Another limitation is the perspective chosen for this study. A health provider perspective only includes costs borne by the health provider and excludes private costs and costs to employers in the form of production losses. A societal perspective that considers all costs regardless of who incurs them is recommended in the literature [5]. However, there is no consensus on whether productivity costs should be included in cost-effectiveness analyses. Nor is there any consensus on how such costs should be valued if they are included [51, 52]. The reason for choosing a provider perspective in this study was that the provider covers most of the costs including travel costs. Another argument is that shorter health visits might not represent production losses at all. Some types of work can be postponed until the patient returns or the work can be handled by a colleague, for example [5].

To use episode of care as an effectiveness measure assumes that there is no difference in health outcomes for the patients, which seems to be a reasonable assumption. A range of evidence has demonstrated that videoconferencing for a variety of conditions produces similar health outcomes to treatment delivered in person [12, 24, 25]. However, using episode of care as an effectiveness measure when analysing the cost effectiveness of an intervention can miss important benefits such as easier access to medical care, avoidance of burdensome travel, and a feeling of improved continuity of care.

Another challenge of economic analyses in the telemedicine field is generalisability. High diversity in terms of specialty, technology, applications, objectives, context, and stakeholders can be a major challenge for economic evaluations [12, 53]. The local setting will decide the most important cost parameters in an evaluation such as travel costs, the need for investment in infrastructure and technologies, prices, and the opportunity costs of health professionals. The evaluation result of a particular telemedicine and e-health service is of most value in the setting where the evaluation was conducted. In this modelling study, data from the literature were used to establish the structure of the decision problem, making the result more transferable to similar clinical settings. The model is designed to be transparent and includes relatively few assumptions that can be easily tested. This modelling study is also transparent in terms of the model inputs, making it easy to change the medical specialty and the local cost parameters.

This modelling study lacks a probabilistic sensitivity analysis because the data inputs were only available as point estimates. Future models of other telemedicine applications might benefit from a formal test of the uncertainties in a full probabilistic sensitivity analysis.

VI. Conclusion and Future Work

This paper proposes a generic economic model describing the decision problem associated with investing in videoconferencing as part of providing specialist consultations. The generic model can be useful as a template for more specific models assessing real-time telemedicine in designated areas in the Helse Nord region. This work presents one such specific model illustrating the expected outcomes in the field of urology. The models presented can be used to clarify the options of interest, to assess potential costs and benefits, and to determine whether further analysis is needed to enable informed decision making in the field. Future work should develop a broader model that includes the use of telehealth and e-health services in a home care setting.

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Competing Interest

The author declares no competing interest.

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