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**Title: Effectiveness of telemedicine: a systematic review of reviews**

**Short title: Effectiveness of telemedicine**

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**Abstract**

**Objectives:** To conduct a review of reviews on the impacts and costs of telemedicine services.

**Methods:** A review of systematic reviews of telemedicine interventions was conducted. Interventions included all e-health interventions, information and communication technologies for communication in health care, Internet-based interventions for diagnosis and treatments, and social care if important part of health care and in collaboration with health care for patients with chronic conditions were considered relevant. Each potentially relevant systematic review was assessed in full text by one member of an external expert team, using a revised check list from EPOC (Cochrane Effective Practice and Organisation of Care Group) to assess quality. Qualitative analysis of the included reviews was informed by principles of realist review.

**Results:** In total 1593 titles/abstracts were identified. Following quality assessment, the review included 80 heterogeneous systematic reviews. Twenty one reviews concluded that telemedicine is effective, 18 found that evidence is promising but incomplete and others that evidence is limited and inconsistent. Emerging themes are the particularly problematic nature of economic analyses of telemedicine, the benefits of telemedicine for patients, and telemedicine as complex and ongoing collaborative achievements in unpredictable processes.

**Conclusions:** The emergence of new topic areas in this dynamic field is notable and reviewers are starting to explore new questions beyond those of clinical and cost effectiveness. Reviewers point to a continuing need for larger studies of telemedicine as controlled interventions, and more focus on patients' perspectives, economic analyses and on telemedicine innovations as complex processes and ongoing collaborative achievements. Formative assessments are emerging as an area of interest.

## **Introduction**

Previous reviews of telemedicine have concluded that irrefutable evidence regarding the positive impact of telemedicine on clinical outcomes still eludes us. One review [1] of more than 150 articles concluded that *potential* effectiveness could only be attributed to teleradiology, telepsychiatry, transmission of echocardiographic images and consultations between primary and secondary health providers. Another systematic review [2] that assessed more than 1300 papers making claims about telemedicine outcomes found only 46 publications that actually studied at least some clinical outcomes. A review that analyzed the suitability of telemedicine as an alternative to face-to-face care [3] concluded that establishing systems for patient care using telecommunications technologies is feasible; however, the studies provided inconclusive results regarding clinical benefits and outcomes. A report on peer-reviewed literature for telemedicine services that substituted face-to-face services with ICT based services at home and in offices or hospitals [4] identified 97 articles that met the inclusion criteria for analysis. The authors concluded that telemedicine is being used even if the use is not supported by high quality evidence. Reviews on cost outcomes have fared similarly. A study focused on cost effectiveness interventions concluded that there is no good evidence that telemedicine is or is not a cost effective means for delivering healthcare [5].

The quality of studies is a recurrent concern in these reviews [1] [2] [4] [5] [6]. There is also a debate about appropriate research methodologies. For example, economic analysis of telemedicine has not yet met accepted standards [5]; there is a relative lack of exploration of the socio-economic impact of telemedicine [7]; evidence on factors promoting uptake of telemedicine is lacking [8]; there is relatively undeveloped use, at the time, of qualitative methods [9]; many studies have not been well-designed [4] [10]; and, considering perceived difficulties of building a robust evidence base for recent innovations, researchers have argued that simulation modelling needs further development [11].

The lack of consensus raises questions about the quality of research evidence in terms not only of the data collected and analysed, but also in terms of the approaches to evaluation, that is, the underlying methodologies used, which may not be capable of addressing the questions to which different stakeholders seek answers. Others have noted that evaluation traditions do not sufficiently collaborate to cross borders and that a common language for evaluation is missing [12].

This paper reports on research funded under EU SMART 2008/0064, which sought to review the evidence on the effectiveness of telemedicine with particular reference to both outcomes and methodologies for evaluation. This paper focuses mainly on the evidence about effectiveness, and assesses the range of conclusions drawn by reviewers about the effectiveness of telemedicine and the

gaps in the evidence base. A companion paper focuses on the methodological issues and recommendations [13].

## **Objectives**

The objective of the work was to conduct a review of reviews on the impacts and costs of telemedicine services and consider qualitative and quantitative results, with the purpose of synthesizing evidence to date on the effectiveness of telemedicine. The key questions addressed were firstly, how are telemedicine services defined and described in terms of participants, interventions, comparisons and outcome measures; secondly, what are the reported effects of telemedicine; thirdly which methodologies were used to produce knowledge about telemedicine in studies included; fourthly, what are the strengths and weaknesses of these methodologies, including HTA methodologies; and finally what are the knowledge gaps and what methodologies can be recommended for future research? The present paper addresses the first two of these questions, and identifies assessments of the evidence base provided within the reviews and knowledge gaps in terms of outcomes.

## **Methods**

An initial search identified systematic reviews of telemedicine published from 1998. A systematic review was defined as an overview with an explicit question and a method section with a clear description of the search strategy and the methods used to produce the systematic review. The review should also report and analyse empirical data. In addition, reviews which described or summarised methods used in assessing telemedicine were included. Because of the large number of reviews retrieved, a decision was taken to include only reviews published from 2005 and onwards in the final review.

### ***Inclusion criteria***

#### *Population/participants*

Systematic reviews on patients and consumers, health professionals and family caregivers, regardless of diagnoses or conditions, were included in the searches for systematic reviews.

#### *Interventions*

All e-health interventions, information and communication technologies (ICT) for communication in health care, Internet-based interventions for diagnosis and treatments, and social care if an important part of health care and in collaboration with health care for patients with chronic conditions were considered relevant.

#### *Comparisons*

Reviews of studies comparing telemedicine to standard care or to another type of care, as well as reviews of studies comparing different e-health solutions were included.

#### *Outcomes*

Only reviews reporting relevant outcomes were included, specified as health related outcomes (morbidity, mortality, quality of life, patient' satisfaction), process outcomes (quality of care, professional practice, adherence to recommended practice, professional satisfaction) and costs or resource use. Systematic reviews reporting emerging issues, such as an unexpected finding or important new insights were also included.

#### *Languages*

No articles were excluded based on language, although the main focus of the project was telemedicine in Europe.

### **Exclusion criteria**

#### *Design*

Reviews considered not systematic, including commentaries and editorials, were excluded. Systematic reviews with major limitations (low quality reviews) according to a revised checklist for systematic reviews from EPOC (Cochrane Effective Practice and Organisation of Care Group) were excluded.

If the same authors had produced several publications of the same review, the most updated and/or the full report of the review was selected, and other versions excluded. Dissertations, symposium proceedings, and irretrievable documents were excluded.

#### *Participants*

Studies with participants considered not relevant for the review, for instance studies on use of ICT on people outside health care were excluded. Animal studies were excluded.

#### *Interventions considered not relevant for the review*

Other exclusions were studies on interventions considered not relevant for the review, such as studies on Internet and other ICT media used for information seeking; quality of information on the Internet; Internet-based education of students and health professionals, including use of games; medical technology in clinical practice in general, i.e. medical and surgical examinations and treatments based on computer technologies, except when used as remote diagnosis and treatment (tele-health); ordinary use of electronic patient records; use of telephone (including cell phones) only; E-health as only a very limited part of an intervention; use of Internet for surveys and research; online prescriptions; mass media interventions and veterinary medicine.

#### *Outcomes*

Articles without relevant outcomes, i.e. not on the list of outcomes specified above under inclusion criteria, were excluded.

### **Information sources**

Literature searches of the following databases: ACM Digital Library (ACM - The Association for Computing Machinery), British Nursing Index, Cochrane library (including Cochrane database of systematic reviews (CDSR), Database of reviews of effects (DARE), Health Technology Assessment Database (HTA), CSA, Ovid Medline, Embase, Health Services/Technology Assessment Text (HSTAT),

International Network of Agencies for Health Technology Assessment (INAHTA), PsycInfo, Pubmed, Telemedicine Information Exchange (TIE), Web of Science. The main search was performed in February 2009, and an updated search was performed in July 2009.

### **Search**

The search strategies are available on the website: (to be inserted).

### **Study selection**

Based on the criteria for inclusion and exclusion, AGE and SF independently screened the lists of titles/abstracts identified through searches for systematic reviews. Any discrepancies were solved by discussion with the third member of the team, AB. The potentially relevant systematic reviews were retrieved in full text.

### **Data collection process**

Data collection was carried out on-line using a data extraction form. Each potentially relevant systematic review was assessed in full text by one member of an expert panel of reviewers. A revised check list from EPOC (Cochrane Effective Practice and Organisation of Care Group) was used to assess the quality of the systematic reviews. The quality domains assessed according to this checklist were methods used to identify, include and critically appraise the studies in the review, methods used to analyse the findings and an overall assessment of the quality of the review. The review team (AGE, AB and SF) subsequently checked review reports for agreement regarding the inclusion and exclusion criteria.

### **Data items**

Data on type of participants, interventions and outcomes included in the reviews were collected. Other data items were: geographical coverage of review, time frame of included studies, range of data collection methods used in studies included in the reviews, disciplines/areas covered and methodological traditions included in the review. The reviewers were also asked to indicate emerging issues identified by the authors of the reviews.

### **Quality of systematic reviews and risk of bias in individual studies**

The members of the expert team assessed the quality of the systematic reviews, including questions regarding the degree to which the systematic reviewers had assessed risk of bias in individual studies.

Systematic reviews with major limitations were excluded. We assessed the methodological quality of studies in the field of telemedicine based on the review authors' assessments of risk of bias in the primary studies they had included.

### **Summary measures and synthesis of results**

The authors analysed the data collected by the members of the expert team. Due to the expected heterogeneity of studies, regarding participants, interventions, outcomes and study designs, a quantitative summary measure of the results was not planned. We did a qualitative and narrative summary of the results of the systematic reviews. The results of the literature review were presented and discussed in two workshops intending to validate results. In the first workshop different user groups took part and in the second workshop methodology experts participated. The analysis was inspired by principles of realist review [14], considered appropriate for complex interventions.

## **Results**

We identified 1593 records through the searches and excluded 1419 following screening. We retrieved 174 potentially relevant articles in full text. We excluded 94 of these based on the pre-specified inclusion and exclusion criteria. The qualitative synthesis below relate to 73 of the 80 included articles.

The results of the 80 systematic reviews included are summarised in seven tables in Appendix 1. Tables one through six list populations, interventions, outcomes, results and conclusions for the reviews cited in this paper, according to the headlines presented in the discussion below. Table seven list the 7 included reviews not cited in this paper.

### **Telemedicine is effective**

Twenty-one reviews (Table 1) concluded that telemedicine works and has positive effects. These include therapeutic effects, increased efficiencies in the health services, and technical usability.

Types of interventions that were found to be therapeutically effective include on-line psychological interventions [15]; programmes for chronic heart failure that include remote monitoring [16]; home telemonitoring of respiratory conditions[17];web and computer based smoking cessation programmes [18]; telehealth approaches to secondary prevention of coronary heart disease [19]; telepsychiatry [20]; virtual reality exposure therapy (VRET) for anxiety disorders [21]; robot-aided therapy of the proximal upper limb [22]; internet and computer-based cognitive behavioural therapy for the treatment of anxiety [23] [24]; home telehealth for diabetes, heart disease and chronic obstructive pulmonary disease [25]; and internet based physical activity interventions [26]. A review comparing telepsychiatry and face to face work [27] found no differences between the two, and suggested that telepsychiatry will increase in use, particularly where it is more practical.

Interventions that are effective in reducing health service use include vital signs monitoring at home with telephone follow-up by nurses [28]; computerised asthma patient education programs [29]; and home monitoring of diabetes patients [30].

Technical effectiveness and reliability are reported in respect of remote interpretation of patient data [31]; smart home technologies [32]; and home monitoring of heart failure patients [33].

One review concluded that home based ICT interventions in general give comprehensive positive outcomes for chronic disease management, despite only identifying a small number of heterogeneous studies [34].

### **Telemedicine is promising**

Nineteen reviews (Table 2) were less confident about the effectiveness of telemedicine, suggesting that it is promising, or has potential, but that more research is required before it is possible to draw firm conclusions. In some cases, in which the same conditions and interventions are discussed, these more tentative conclusions must temper those of authors who find conclusive evidence.

One review [35] for example found internet-delivered CBT to be a 'promising' and 'complementary' development, but did not provide the endorsements that others [23] [24] did for CBT for the more specific conditions of anxiety and depression. Similarly psychotherapy using remote communication technologies was seen as promising [36], but still requiring more evidence.

Areas in which review authors agreed that telemedicine shows therapeutic promise, but still requires further research, include virtual reality in stroke rehabilitation [37] [38]; improving symptoms and behaviour associated with and knowledge about specific mental disorders and related conditions [39]; diabetes [40] [83]; weight loss intervention and possibly weight loss maintenance [41]; and alcohol abuse [88].

Other authors found promise in terms of health service utilisation. One review [42] for example suggested that asynchronous telehealth developments could result in shorter waiting times, fewer unnecessary referrals, high levels of patient and provider satisfaction, and equivalent (or better) diagnostic accuracy. Another [43] found that home telehealth has a positive impact on the use of many health services as well as glycaemic control of patients with diabetes.

Positive patient experiences were highlighted as promising in relation to home telemonitoring for respiratory conditions [17]. There is potential for using Internet/web based services for cancer patients in rural areas [44], and telemonitoring can empower patients with chronic conditions [45].

Promising impacts on service delivery were identified [46] [47] in use of electronic decision support systems and telemedicine consultations promise to support improved delivery of tPA in patients with stroke (a treatment which requires to be administered within three hours) [48]. Computer reminders to professionals at the point of care show 'small to modest improvements' in



professional behaviour, but studies are heterogeneous and interventions complex, making these difficult to understand [49].

### **Evidence is limited and inconsistent**

Twenty two reviews (Table 3) however concluded that the evidence for the effectiveness of telemedicine is still limited and inconsistent, across a wide range of fields.

In terms of therapeutic effectiveness, there is some limited evidence regarding telemonitoring for heart failure [50]; despite reviewers suggesting that electronic transfer of self monitored results has been found to be feasible and acceptable in diabetes care, they find only weak evidence for improvements in HbA1c or other aspects of diabetes management [51]; others found only weak evidence of benefit relating to informatics applications in asthma care [52]; and no evidence of improvement in clinical outcomes following teleconsultation and video-conferences in diabetes care[53].

Frequently, these reviewers call for further research, notably in the form of RCTs. Examples include calls relating to web-based alcohol cessation interventions [54]; and virtual reality in stroke therapy, despite this being found [37] to be 'potentially exciting and safe'. More work on telemonitoring in heart failure is called for [55]; on e-therapy for mental health problems [56]; on smart home technologies [57]; and on technological support for carers of people with dementia [58]. Others [28] underlined that lack of evidence does not imply lack of effectiveness, and that in many cases interventions are simply 'unproven'. Caution is also urged by reviewers [59] who identified small numbers of heterogeneous studies in relation to chronic disease management. One review [60] found it impossible to draw any significant conclusions about the impact of interventions to promote ICT use by health care personnel.

Several reviewers found that research has been somewhat narrowly focused and suggested further research which takes a broader perspective or a different one. They suggested that telemedicine researchers have not yet asked all the important questions, or conducted research in appropriate ways. For example, in the cases of dermatology, wound care and ophthalmology, it was argued that evaluation has explored ICT-based asynchronous services for efficacy, but outcomes or access issues have not been considered [61]. In a similar vein, although most of the studies of smart homes found technical feasibility, there remain certain topics that require further research, notably, 'technical, ethical, legal, clinical, economical and organisational implications and challenges' [32]. Others [44], whilst seeing significant potential for teleoncology, especially in rural areas, suggested that local studies may be needed to confirm this. A further contribution to the debates about CBT (see above), found that whilst it appears to be effective for panic disorders, social phobia and depression, its effects on obsessive compulsive disorder and anxiety and depression combined remain insufficiently clear [62]. Causal pathways in HbA1c decline in diabetes care

remain unclear, and this conclusion can be linked with the variations in programme designs [63]. Whilst smoking cessation programmes appear to be effective across a range of studies, nevertheless the mechanisms of action are not well understood [64].

Telemedicine is a dynamic field, and new studies and new systematic reviews are rapidly being published. As telemedicine extends into new clinical areas, it is unsurprising that reviewers give renewed accounts of limited evidence. Some examples of new areas from our review include little research on health promotion provided through the Internet [65]; a Cochrane review that found no studies of smart homes that met their inclusion criteria [57]; a review of studies on spiritual care that found little systematic research in this area [66]; and a review concluding that formative evaluation is needed for remote monitoring in hypertension [90].

### **Economic analysis**

An important emerging issue from our review is the lack of knowledge and understanding of the costs of telemedicine (Table 4).

Several reviewers suggested that telemedicine seemed to be cost-effective, but few draw firm conclusions. One review found that 91% of the studies showed telehomecare to be cost-effective, in that it reduced use of hospitals, improved patient compliance, satisfaction and quality of life [67]. This was the clearest conclusion, with others being much more cautious: telemedicine was found to be cost-effective for chronic disease management, but the authors cautioned that studies were few and heterogeneous [34]. A comparison of the costs of telemonitoring and usual care for heart failure patients found that telemonitoring could reduce travel time and hospital admissions, whilst noting that benefits are likely to be realised in the long term [68]. Others found home telehealth for chronic conditions to be cost-saving, though underlining that studies were generally of low quality [25]. One review found remote interpretation in medical encounters to be more expensive than its alternatives [31].

Other reviewers did not find good evidence about cost-effectiveness; the cost-effectiveness of home telecare for older people and people with chronic conditions is uncertain [28]; there is a lack of consistent results regarding costs of synchronous telehealth in primary care [69]; there is little evidence for the economic viability of home respiratory monitoring [17]; the cost-effectiveness of IT in diabetes care is undetermined [40]; one review was able to identify only one study of the costs of CBT, with significant weaknesses [70], with another finding little evidence in the same area [62].

A particular limitation identified in terms of costs concerns the wider social and organisational costs of telemedicine. One review found that a societal perspective on costs has not yet been developed for home telehealth [71] and

another highlighted the need to consider not only costs to health services of interventions, but also costs to service users and their social networks [72].

### **Is telemedicine good for patients?**

A second emerging issue concerns patient satisfaction with telemedicine, and indications that telemedicine may alter the relationships between patients and health professionals (Table 5).

One review found that health service users with ICT used in support, education and virtual consultation feel more confident and empowered, with better knowledge and improved health outcomes, as well as experiencing better nurse-patient relationships[73]. The reviewers call for more research on the mechanisms for these changes. Generally there is evidence of high patient satisfaction ratings for telerehabilitation, but reviewers argue that more process research, case studies and qualitative studies are needed to improve our understanding of these outcomes [74]. Interactive health communication applications (IHCAs) for people with chronic disease appear to give benefit in terms of improved support, better knowledge and improved health outcomes, but the authors asked for more larger studies to be conducted [75].

Others found no consistent results regarding user experiences, though suggested that access can be improved [69]. Alongside development of technologies which aim to benefit patients and citizens as well as professionals, we need research on the impacts of technologies for these groups [76]. An example is that information websites relating to dementia are geared more to carers than to people with dementia themselves, and that the websites do not usually offer personalised information [77].

### **Asking new questions**

We have already noted the emergence of new topic areas in this dynamic and complex field. The focus on patient benefits however indicates a more basic development, namely that reviewers are starting to explore new questions beyond those of clinical and cost effectiveness. Our review produced two key examples (Table 6). Firstly, a review that identified gender differences in computer-mediated communications relating to on-line support groups for people with cancer cautioned that studies are limited and heterogeneous [78]. Nevertheless, the authors suggested that this issue needs to be considered by those designing interventions of this kind. This implies a consideration that telemedicine is an ongoing intervention where users influence its development and hence that effectiveness of outcome is a complex collaborative achievement. Secondly, a review focusing on stroke thrombolysis service configurations, their potential impact and ways of recording data to inform which configuration could be most suitable for a particular situation, highlighted the need to consider a wider range of service delivery issues [79]. Similarly, it was argued that in post stroke patients, the consideration of caregivers' mental health and high levels of patient satisfaction should be an integral element of studies [80].

Furthermore, some of the papers included in the review explored issues which can inform the future development of telemedicine, that is, they provide formative assessments. Examples include a review of 104 definitions of telemedicine [81] which, in identifying four broad types of definitions, suggested how stakeholder interests can alter perceptions of priorities in telemedicine interventions, such that some may focus on delivering healthcare over a distance and others on the potential of technology per se; and work arguing that clinical and technical guidelines can inform the future development of telemedicine and facilitate evaluation [20] [82].

### **Reflections on the methodology of our study**

Our study is a review of systematic reviews. There are some inherent weaknesses in this approach. In general we have to rely on the information in the included reviews. The quality of the reviews may vary; the reviews may have done a poor job in specifying their inclusion and exclusion criteria, the searches may not be comprehensive, the review authors may not have assessed or extracted data from the primary studies adequately, nor analysed and synthesised the findings across the studies properly. But even using high quality reviews, we necessarily lose information and details that we can only find if we go back to the primary studies.

Although we did a thorough job in developing the search strategy and identified a vast amount of reviews on the effects of telemedicine, we might have missed relevant systematic reviews.

Some of the included reviews are probably outdated. Studies that are published after the search date in the reviews are not included. Ideally we could have supplemented the review with more recent primary studies not included in the reviews, but we did not have the resources to do this.

We did not check whether reviews included the same references. Several reviews have studied similar or overlapping topics, and have at least partially included the same studies. It may therefore be that evidence is counted twice, or that different interpretations of effectiveness are given by review authors. We have not analysed the degree to which there are discrepancies in the analyses of similar studies, nor the reasons for different interpretations of the same findings, for instance did we not analyse the heterogeneity of the results among the reviews based on the quality of the reviews.

The data collection and assessment of each included review was accomplished by one external expert, while two is considered to be optimal in order to reduce risk of bias. We did not train the data extractors, and we did not pilot the data extraction form. The experts were not completely consistent in their judgments. This limitation was partly due to the resources and organisation of the project, in that two workshops were held, intending to validate results. In addition, the

review team made a quality check of the reviews by comparing the reported data with information in the full text papers. Any unclear themes were discussed in the team to reach consensus.

We have limited information regarding effect sizes and the strength of evidence for the outcomes that we have studied.

We have however demonstrated that it is possible to make such a large overview in quite a short time, involving both methodology and content experts. We have used systematic methods in the literature searches and the assessment of the reviews, and we have excluded reviews of low methodological quality.

In combining rigorous and systematic methods with a pragmatic approach we have produced a relevant and rich overview of the field.

### **Conclusions**

Despite large number of studies and systematic reviews on the effects of telemedicine, high quality evidence to inform policy decisions on how best to use telemedicine in health care is still lacking. Large studies with rigorous designs are needed to get better evidence on the effects of telemedicine interventions on health, satisfaction with care and costs. As the field is rapidly evolving, different kinds of knowledge are also in demand, e.g. a stronger focus on economic analyses of telemedicine, on patients' perspectives and on the understanding of telemedicine as complex development processes, and effectiveness and outcome as ongoing collaborative achievements. Hence formative assessments are also pointed out as an area of weakness and interest.

### **Summary Table**

<b>What was already known on this topic</b>
<ul style="list-style-type: none"> <li>• Evidence regarding the effectiveness of telemedicine is patchy and incomplete</li> <li>• The quality of much of the research conducted is poor</li> </ul>
<b>What this study added to our knowledge</b>
<ul style="list-style-type: none"> <li>• The evidence base is accumulating robust knowledge about the effectiveness of telemedicine</li> <li>• As the field is rapidly evolving however, new knowledge is constantly needed</li> <li>• Continuing areas of weakness but also of great interest include economic analyses, understandings of patient perspectives, of effectiveness and outcomes as complex and ongoing collaborative achievements, and formative assessments</li> </ul>

### **Author contributions**

Corresponding Author: Anne Granstrøm Ekeland

- Leading the description of the project, the review team and the work on the literature review:
  - profile of the protocol, including search strategies and selection criteria
  - reading abstracts and selecting reviews for full text assessment
  - development of the online proforma for reviewers
  - collection and administration of PDF's for the literature database
  - reviewing papers
  - coordinating and administrating the reviews from external experts
  - organization and analysis of data
- Leading the work on the paper
  - analysis of data, scientific profile
  - write up first draft of abstract and conclusion, and development of the full paper
  - approving the full paper
  - submission process

**Second Author: Alison Bowes**

- Contributing to the description of the project, especially the part on the literature review and the work packages
- Contributing substantially to the literature review:
  - the profile and development of the protocol, including search strategies and selection criteria
  - reading abstracts and selecting papers for full text assessment
  - developing and implementing the online proforma for reviewers
  - reviewing papers
- Substantial contributions on the paper
  - analysis of data, scientific contributions
  - write up of first draft of results, commenting and developing later versions

**Third Author: Signe Flottorp**

- Contributions to the description of the methodologies and the conduct of the review
  - the work on the protocol and the literature search strategies
  - reading abstracts and selecting reviews for full text assessment
  - reviewing papers
- Contributions to the paper
  - write up of first draft of the methods section and commenting later drafts
  - commenting and contributing to the scientific discussions

**Conflict of interest statement**

There are no conflicts of interest to declare.

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## **Appendix 1 Tables 1 – 7**

In these tables, columns listing results and conclusions quote from the authors' work. Where a review appears in more than one table, this reflects the range of evidence produced. Full access to a searchable database of abstracts of items included in the review will be available on the MethoTelemed website, which also includes guidance for evaluating telemedicine.

[www.telemed.no/MethoTelemed](http://www.telemed.no/MethoTelemed)

**Table 1: Systematic reviews reporting that telemedicine is effective**

Reference	Conditions included	Geographic area	Service/ Intervention	Outcome	Authors' summary of results	Authors' conclusions
Barak et al 2008 [15]	Mental health	Not stated	Internet based psychotherapy	Behavioural, Health, Perception/ satisfaction, Social	64 studies included covering 94 services. The overall mean weighted effect size was 0.53, similar to the average effect size of traditional, face-to-face therapy. Comparison between face-to-face and Internet intervention across 14 studies showed no differences in effectiveness.	Internet based intervention is as effective as face to face intervention.
Clark et al 2007 [16]	Cardio-vascular (CHF)	All countries	Remote monitoring, telephone support	Behavioural, Cost/economic, Health	14 studies (RCTs) included. 4 evaluated telemonitoring, 9 structured telephone support, and one both. Remote monitoring programmes reduced the rates of admission to hospital for chronic heart failure by 21% and all cause mortality by 20%. 3 studies reported quality of life improvements and 4, reduced cost, 1 found no gain in cost effectiveness.	Programmes for chronic heart failure that include remote monitoring have a positive effect on clinical outcomes in community dwelling patients with chronic heart failure
Jaana et al 2009 [17]	Respiratory conditions	USA, Europe, Israel, Taiwan	Remote monitoring	Behavioural, Cost/economic, Feasibility/pilot, Health, Perception/ satisfaction	23 studies included. Good levels of data validity and reliability were reported. However, little quantitative evidence exists about the effect of remote monitoring on patient medical condition and utilization of health services. Positive effects on patient behaviour were consistently reported. Only 2 studies performed a detailed cost analysis.	Home telemonitoring of respiratory conditions results in early identification of deteriorations in patient condition and symptom control. Positive patient attitude and receptiveness of this approach are promising. However, evidence on the magnitude of clinical and structural effects remains preliminary, with variations in study approaches and an absence of robust study designs and formal evaluations.
Myung et al 2009 [18]	Smoking cessation	Worldwide	Web and computer based programmes	Behavioural	22 studies included (RCTs). In a random-effects meta-analysis of all 22 trials, the intervention had a significant effect on smoking cessation. Similar findings were observed in 9 trials using a Web-based intervention, (and in 13 trials using a computer-based intervention Subgroup analyses revealed similar findings for different levels of methodological rigor, stand-alone versus supplemental interventions, type of abstinence rates employed, and duration of follow-up period, but not for adolescent populations.	The meta-analysis of RCTs indicates that there is sufficient clinical evidence to support the use of Web- and computer-based smoking cessation programs for adult smokers.
Neubeck et al 2009 [19]	Cardio-vascular (CHD)	USA (3 studies), Norway (1), Canada (3), Australia (3), Germany (1)	Communication using ICT, patient-professional	Behavioural, Health, psychosocial state, quality of life	11 studies included (RCTs). Telehealth interventions were associated with non-significant lower all-cause mortality than controls. These interventions showed a significantly lower weighted mean difference at medium long-term follow-up than controls	Telehealth interventions provide effective risk factor reduction and secondary prevention. Provision of telehealth models could help increase uptake of a formal secondary prevention by those who do not access cardiac rehabilitation and narrow the current evidence-

**Table 2: Systematic reviews reporting that telemedicine is promising**

Reference	Conditions included	Geographic area	Service/ Intervention	Outcome	Authors' summary of results	Authors' conclusions
Cuijpers et al 2008 [35]	Pain and other health problems	Global	CBT via internet	Health	12 studies included (RCTs). 3 studies focused on pain, 3 on headache, and 6 on other health problems. Effects found for Internet interventions targeting pain and headache were comparable to effects found for face-to-face treatments, and the same was true for interventions aimed at headache. Other interventions also showed some effects, which differed across target conditions.	Internet-delivered cognitive-behavioural interventions are a promising addition and complement to existing treatments. The Internet will most likely assume a major role in the future delivery of cognitive-behavioural interventions to patients with health problems. More research on eCBT is needed.
Bee et al 2008 [36]	Anxiety and depression	Not stated	Psychotherapy mediated by remote communication technology	Behavioural outcomes	13 studies included. Pooled effect sizes for remote vs. conventional services were 0.44 for depression and 1.15 for anxiety related disorders. Few studies compare remote and face-to-face psychotherapy. Data suggest that good effects may not be dependent on patient and therapist being co-located, but the evidence is limited.	Remote therapy has the potential to overcome some of the barriers to conventional psychological therapy services, but large scale trials are needed.
Crosbie et al 2007 [37]	Stroke	Not stated	Virtual reality (VR) in stroke rehabilitation	Behavioural , Health, Safety	11 studies included. 5 cover upper limb rehabilitation, 3, gait and balance, 2 cognitive interventions, and one both upper and lower limb rehabilitation. 3 were AACPDM Level I/Weak, 2 Level III/Weak, 3 Level IV/Weak and 3 Level V quality of evidence. 3 RCTs obtained statistical significance, and 8 studies found VR based therapy to be beneficial. None reported any significant adverse effects.	VR is a potentially exciting and safe tool for stroke rehabilitation but its evidence base is too limited by design and power issues to permit a definitive assessment of its value. Thus, while the findings of this review are generally positive, the level of evidence is still weak to moderate, in terms of research quality. Further study in the form of rigorous controlled studies is warranted.
Henderson et al 2007 [38]	Stroke	Global	Virtual reality (VR) in stroke rehabilitation	Health	6 studies included. The results of the reviewed studies suggest that immersive VR may have an advantage over no therapy in the rehabilitation of the upper limb in patients with stroke, but the results are still questionable.	Current evidence on the effectiveness of VR in the rehabilitation of upper limb in patients with stroke is limited but sufficiently encouraging to justify further research in this area.
Griffiths & Christensen 2006 [39]	Mental health	Global	Internet interventions	Behavioural, Health, Perception/ satisfaction	16 papers included (reporting 15 RCTs). The review demonstrates that Internet interventions show promise as a means of improving symptoms and behaviour associated with and knowledge about specific mental disorders and related conditions.	Most interventions were reported to be effective in reducing risk factors or improving symptoms, although many of the studies had methodological limitations. Three of the interventions that reported positive outcomes are available without charges to the public.
Jackson et al 2006 [40]	Diabetes	Not stated	Computer assisted interactive IT	Behavioural, Cost/economic, Health	27 papers included (reporting 26 studies) Significant impacts on behavioural, clinical and structural levels	There is growing evidence that emerging IT may improve diabetes care. Future research should characterize benefits in the long term, establish methods to evaluate clinical outcomes, and determine the cost-effectiveness





**Table 3: Systematic reviews reporting that evidence on telemedicine is limited and inconsistent**

Reference	Conditions included	Geographic area	Service/ Intervention	Outcome	Authors' summary of results	Authors' conclusions
Chaudhry et al 2007 [50]	Heart failure	Telephone based monitoring: Argentina (1 study), USA 4 studies. Automated monitoring USA 1 study. Automated physiologic monitoring USA 1 study. Comparisons of 2 or more methods of telemonitoring: Germany/the Netherlands and UK: one study, USA 1 study	Remote monitoring	Cost/economic, Health	9 studies included. 6 suggested reduction in all-cause and heart failure hospitalisations with telemonitoring. Of the 3 negative studies, 2 enrolled low-risk patients and patients with access to high quality care, and 1 enrolled a very high-risk Hispanic population. Studies comparing forms of telemonitoring demonstrated similar effectiveness. Intervention costs were higher with more complex programs..	The evidence base for telemonitoring in heart failure is currently quite limited. Based on the available data, telemonitoring may be an effective strategy for disease management in high-risk heart failure patients.
Farmer et al 2005 [51]	Diabetes	Not stated	Self monitoring, Data transfer	Cost/economic, Feasibility/pilot, Health, Organizational, Perception/satisfaction	26 studies included. Electronic transfer of glucose results appears feasible in a clinical setting. Only two of the RCTs included more than 100 patients, and only three extended to 1 year. Only one study was designed to show that telemedicine interventions might replace clinic interventions without deterioration in HbA Results pooled from the nine RCTs with reported data did not provide evidence that the interventions were effective in reducing HbA to 0.04%).(p1372)	Telemedicine solutions for diabetes care are feasible and acceptable, but evidence for their effectiveness in improving HbA or reducing costs while maintaining HbA levels, or improving other aspects of diabetes management is not strong. Further research should seek to understand how telemedicine might enhance educational and self-management interventions and RCTs are required to examine cost-effectiveness.
Sanders & Aronsky 2006 [52]	Asthma	USA	Diagnostics, prevention and monitoring, decision support tools, patient-centred education tools	Behavioural, Health, Social	64 studies included, but only 21 prospective trials. The mean quality score was 6.6 (range: 3 to 10). None of the studies reported on allocation concealment. Of the 13 studies that reported a clinical outcome, seven reported a positive effect of the computerised intervention and six reported no significant change. Of the 8 studies reporting a non-clinical outcome, seven reported a statistically significant positive effect of the computerised intervention	Most studies took place in the outpatient clinic environment, with minimal study of the emergency department or inpatient settings. Few studies demonstrated evidence of computerised applications improving clinical outcomes
Verhoeven et al 2007 [53]	Diabetes	Worldwide	Teleconsultation and videoconferencing	Cost/economic, Health, Perception/satisfaction, Technology related	39 studies included. They found no significant statistical heterogeneity among the pooled randomised controlled trials that they identified within this group. Most of the improvements found concerned (a) satisfaction with technology, (b) improved metabolic control or (c) cost savings. No significant benefits were found in relation to (a) quality of life, (b)	The study did not support any conclusion that these interventions improved clinical values (e.g. blood pressure). The authors argued that diversity in design of the studies meant that strong conclusions were premature.

**Table 4: Emerging issue 1: Economic analysis**

Reference	Conditions included	Geographic area	Service/ Intervention	Outcome	Authors' summary of results	Authors' conclusions
Rojas & Gagnon 2008 [67]	All	Worldwide	Telehomecare, (THC)	Cost/economic, Health, Perception/ satisfaction	23 studies included. THC was found to be a cost-effective alternative to traditional approaches in 91% of the studies. Main benefits included decreased hospital utilisation; improved patient compliance with treatment plans; improved patient satisfaction with health services and improved quality of life.	The authors argue that one of the major disadvantage is of THC studies has been the failure to adopt a set of common indicators to calibrate their cost effectiveness.
Gaikwad & Warren 2009 [34]	Chronic disease	Not stated	Home based ICT interventions	Behavioural , Cost/economic, Health, Perception/ satisfaction	27 studies included. These systems can improve functional and cognitive patient outcomes in chronic disease and reduce costs. However, the research is not yet sufficiently robust.	Telecare, telehealth etc have positive clinical and cost outcomes - although studies are few in number and heterogeneous. Better evidence-based outcome measures are needed, especially regarding costs and physician perspectives.
Seto 2008 [68]	Heart failure	Worldwide	Remote monitoring	Cost/economic	11 studies included. The author considered a variety of direct and indirect cost categories including costs to the health system and costs to the patient. These are described.	Telemonitoring has a positive role to play in reducing costs by reducing re-hospitalisation and travel costs
Tran et al 2008 [25]	Diabetes, heart failure, COPD and other chronic diseases'	Canada focused, but international publications included	Home telehealth	Cost/economic, Health, Perception/ satisfaction	79 studies included. Of the included studies, 26 pertained to diabetes, 35 to chronic heart failure, nine to COPD, and eight to mixed chronic diseases. The comparator "no care" was not identified in any of the included studies, so usual care was used as the comparator throughout the clinical review. Home telehealth appeared generally clinically effective and no patient adverse effects were reported. Evidence on health service utilization was more limited, but promising The economic review suggested cost effectiveness, but the quality of studies was low.	Conclusions relate to the potential for home telehealth in Canada which is seen as positive. However, more research, such as multicentre RCTs, is warranted to accurately measure the clinical and economic impact of home telehealth for chronic disease management to support Canadian policy makers in making informed decisions.
Azarmina & Wallace, 2005 [31]	All	All countries	Remote interpretation in medical encounters	Cost/economic Feasibility/pilot, Health, Organizational, Perception/ satisfaction, Safety	9 studies included. Results showed that time between encounters was reduced, but evidence on consultation length was not consistent. Good client and doctor satisfaction was shown, but those interpreting data preferred to do so face to face. Costs of these interventions are high, but efficiency gains are possible.	The review suggests that remote interpretation is an acceptable and accurate alternative to traditional methods, despite the higher associated costs.
Barlow et al 2007 [28]	Elderly people, chronic diseases	Worldwide	Home telecare	Behavioural , Health, Organizational,	68 RCTs and 30 observational studies with 80 or more participants included. Results show that the most effective telecare interventions appear	Having identified where there is evidence of effectiveness, and where it is lacking, the authors conclude that insufficient evidence does



**Table 5: Emerging issue 2: Is Telemedicine good for patients?**

Reference	Conditions included	Geographic area	Service/ Intervention	Outcome	Authors' summary of results	Authors' conclusions
Akesson et al 2007 [73]	All	Worldwide	Support, education/information/ virtual consultation	Behavioural, Feasibility/pilot, Health, Perception/ satisfaction, Quality of life	12 studies included. Three themes identified: support and help, education and information, and telecommunication instead of on-site visiting. Findings show consumers feeling more confident and empowered, with increased knowledge and improved health status due to the ICT resources. Lack of face-to-face meetings or privacy did not appear to be a problem.	ICT can improve the nurse-patient relationship and augment well-being for consumers. More research is needed to measure consumers' experiences and factors that influence it.
Kairy et al 2009 [74]	Physical disabilities	Not stated	Telerehabilitation	Behavioural, Cost/economic, Health, Perception/ satisfaction, Social	28 studies included. Clinical outcomes were generally improved; clinical process outcomes were high; consultation time was longer; patient satisfaction ratings were high. Healthcare utilization evidence was unclear. There is some evidence of potential cost savings.	While evidence is mounting concerning the efficacy and effectiveness of telerehabilitation, high-quality evidence regarding impact on resource allocation and costs is still needed to support clinical and policy decision-making.
Murray et al 2005 [75]	Chronic disease	Not stated	Interactive health communication Applications (IHCA)	Behavioural, Health	24 studies included (RCTs). Computer-based programmes ('Interactive Health Communication Applications') for people with chronic disease had a significant positive effect on knowledge, social support, and clinical outcomes. Results suggest it is more likely than not that IHCA have a positive effect on self-efficacy. IHCA had a significant positive effect on continuous behavioural outcomes. Binary behavioural outcomes also showed a positive effect for IHCA, although this result was not statistically significant. It was not possible to determine the effects of IHCA on emotional or economic outcomes.	IHCAs appear to have largely positive effects on users, in that users tend to become more knowledgeable, feel better socially supported, and may have improved behavioural and clinical outcomes compared to non-users. There is a need for more high quality studies with large sample sizes to confirm these preliminary findings, to determine the best type and best way to deliver IHCA, and to establish how IHCA have their effects for different groups of people with chronic illness
Deshpande et al 2008 (synchronous telehealth) [69]	Chronic disease,	All countries	Home telehealth, in real time	Behavioural, Cost/economic, Feasibility/pilot, Health, Perception/ satisfaction, Safety, Social, Technology related	31 systematic reviews included (11 of high quality). Most reviews and most of the studies they review are low quality. The authors suggest that this illustrates the resource constraints for researchers and policy makers. Nevertheless, weak evidence that real-time telehealth can improve service access, user satisfaction and resource utilization is found. For patients with psychiatric and neurological conditions in remote areas, evidence of benefit is stronger.	Evidence is generally weak and studies of poor quality, but telehealth is nevertheless promising, especially in a Canadian context over a large geographical area.
Koch 2006 [76]	Chronic diseases, elderly population, paediatrics	Country and no of publications USA 238 UK 52	Home telehealth	Cost/economic, Perception/ satisfaction, Feasibility/pilot,	578 studies included. 44% of publications come from the United States, followed by UK and Japan. Most cover vital sign parameter (VSP) measurement and audio/video consultations.	Internationally, we observe a trend towards tools and services not only for professionals but also for patients and citizens. However, their impact on the patient—provider relationship and

**Table 6: Asking new questions**

Reference	Conditions included	Geographic area	Service/ Intervention	Outcome	Authors' summary of results	Authors' conclusions
Mo et al 2009 [78]	All	Not stated	Online support groups	Behavioural, Health, Outcome of posted messages used to categorise gender differences	12 studies included. Half of the studies examined gender differences by comparing male and female cancer discussion boards. Some gender differences were observed in these studies. However, for studies that analysed mixed-gender communities, gender differences were less evident.	Results seemed to reveal gender differences in communications in single-sex online health support groups, and similarities in communication patterns in mixed-sex online health support groups. However, findings should be treated with caution due to the diversity in studies and methodological issues highlighted in the present review.
Price et al 2009 [79]	Stroke	Oceania, Asia, Europe, North America, Europe	Service configurations	Safety, Activity level and response times for thrombolysis treatment	54 studies included. Local service configuration provides less thrombolysis activity than wider collaborations and report as many protocol violations despite their simpler design. Local variations in population density, geography, experts and activity and safety data reporting formats makes it difficult to compare service configurations. Reporting of activity and safety in a standardised format is urged.	Stroke services should continue to publish thrombolysis activity and safety data in a recommended format in order to determine the most suitable configuration for different settings
Deshpande et al 2008 (stroke management) [80]	Stroke	US, Canada, Germany, Italy, Netherlands, China	Acute medicine	Cost/economic, Feasibility/pilot, Health, Perception/satisfaction, Technology related	22 studies included (8 of high quality). Results showed improved access to thrombolysis, acceptable times between hospital arrival and thrombolysis, and decreased need to transfer patients across institutions. Mortality rates, and three and six month functional outcomes were comparable with those of face-to-face stroke care. Mortality rates were also similar. Patients and provider satisfaction was high, though not assessed in detail.	Although it is difficult to draw conclusions from this small sample of studies, the trend suggests that in post-stroke patients, telehealth led to improvements in caregivers' mental health and high levels of patient satisfaction. There was minimal evidence regarding the impact on resource utilization.
Sood et al 2007 [81]	All	Not stated	All	Definitions of telemedicine	104 studies included, which generate 104 definitions. The authors identify four types of definition: 1. Medical: mention of "providing healthcare services". 2. Technological: indication of technology's role. 3. Spatial: "geographical separation of patient and doctor" pertains to or involves nature of space/distance. 4. Benefits: medical care is brought to people when it is not feasible to get people to medical care	The article provides formative evaluation by classifying the different approaches to defining telemedicine and their underlying theoretical assumptions.
Pineau et al 2006 (telepsychiatry) [20]	Psychiatric conditions (adult and pediatric)	Not stated Focus on Canada and USA	Telepsychiatry	Cost/economic, Ethical issues, Legal, Organizational, Technology related, clinical guidelines and technical standards	'About 60' studies included. The authors argue that definition of clinical guidelines and technological standards aimed at standardizing telepsychiatric practice will promote its large scale implementation.	The review concludes that telepsychiatry should be implemented in Québec and provides detailed clinical and technical guidelines for implementation. They add that taking into account human and organizational aspects plays a part in ensuring the success of this type of activity; that legal and ethical aspects must also be considered; and that a detailed economic analysis should be carried out prior to

