Diagnosis, access and outcomes: update of a systematic review of telemedicine services

William R Hersh*, David H Hickam*†, Susan M Severance*, Tracy L Dana*, Kathryn Pyle Krages* and Mark Helfand*†

*Department of Medical Informatics and Clinical Epidemiology, Oregon Health and Science University, Portland, Oregon, USA; †Division of Hospital and Specialty Medicine, VA Medical Center, Portland, Oregon, USA

Summary

Telemedicine services are being increasingly used. Although insurers and other payers are covering some services in the USA, the rationale for these coverage decisions is not always evidence-based. We reviewed the literature for telemedicine services that substitute for face-to-face medical diagnosis and treatment. We focused on three types of telemedicine services: store-and-forward, home-based and office/hospital-based services. Studies were included if they were relevant to at least one of the three study areas, addressed at least one key question and contained reported results. We excluded articles that did not study a service requiring face-to-face encounters (i.e. teleradiology was excluded). Our search initially identified 4083 citations. After review, 597 were judged to be potentially relevant at the title/abstract level. Following a full-text review, 106 studies were included. Store-and-forward services have been studied in many specialties, the most common being dermatology, wound care and ophthalmology. The evidence for their efficacy is mixed. Several limited studies showed the benefits of home-based telemedicine interventions in chronic diseases. Studies of office/hospital-based telemedicine suggest that telemedicine is most effective for verbal interactions, e.g. videoconferencing for diagnosis and treatment in specialties like neurology and psychiatry. There are still significant gaps in the evidence base between where telemedicine is used and where its use is supported by high-quality evidence. Further well-designed research is necessary to understand how best to deploy telemedicine services in health care.

Introduction

Although the use of telemedicine services is widespread, there remains concern about the evidence supporting its effectiveness in improving the quality of or access to health care. In 2001, we published a systematic review of the evidence in the peer-reviewed literature on the efficacy of telemedicine in diagnosis and management decisions, patient outcomes, access to care, patient and physician satisfaction and cost-effectiveness.[1–3] The present paper updates that review. In this study, the effects of telemedicine services on diagnosis and management decisions, patient outcomes and access to care were evaluated on the basis of studies published during the five-year period since our original systematic review was performed. Our goal was to synthesize the scientific evidence on the effectiveness of three categories of telemedicine services: store-and-forward, home-based and office/hospital-based.

Correspondence: Professor William R Hersh, Department of Medical Informatics and Clinical Epidemiology, Oregon Health and Science University, 3181 SW Sam Jackson Park Road, BICC, Portland, OR 97239, USA (*Fax: +1 503 494 4551; Email: hersh@ohsu.edu*)

Our initial report found that while telemedicine was in widespread use, the evidence of efficacy for those uses was lacking. Many of the studies performed prior to the year 2000 used poor methodologies and small sample sizes. Our main conclusion was that the overall quality of the studies evaluating telemedicine services was insufficient to draw conclusions about its efficacy.

For the present report, we define telemedicine as the use of telecommunications technology for medical diagnostic, monitoring and therapeutic purposes when distance and/or time separates the participants. Some workers use the alternative term telehealth to indicate care beyond that provided in medical encounters (e.g. health education, health-related Websites). Other workers use terms focused on medical specialties, such as teledermatology or teleradiology. A telemedicine encounter is the event where clinical services are provided using telemedicine.

The present systematic review examined telemedicine services in three areas: store-and-forward, home-based and office/hospital-based services. Each of these services was evaluated for their efficacy on three measures: diagnosis and management decisions, clinical outcomes and access to care. Studies were assessed from the standpoint of telemedicine being equivalent to, but not necessarily better than, in-person care. The clinical outcomes assessed

in this study were limited to measures of clinical care, such as health status, improvement in clinical variables (e.g. blood glucose or blood pressure) and recovery from disease. We did not evaluate utilization or economic outcomes.

Store-and-forward telemedicine involves the collection of medical data and then their transmission for subsequent interpretation. Store-and-forward systems provide the ability to capture and store digital still or moving images of patients, as well as audio and text data. A store-and-forward system eliminates the need to have the patient and the specialist available at the same time. Store-and-forward is therefore an asynchronous, non-interactive form of telemedicine. It is usually employed as a clinical consultation (as opposed to an office or hospital visit).

Home-based telemedicine services enable health professionals to monitor physiological variables, test results, images and sounds. The information is usually collected in a patient's home or a nursing facility. Post-acute-care hospital patients, patients with chronic illnesses and patients with conditions that limit their mobility often require close monitoring and follow-up. These patients may also be taking medications that require testing and/or titration of dosage. Telemedicine systems use a variety of strategies to accomplish this monitoring. For example, several technologies allow patients to transmit monitoring data directly to a health-care system or to enter it into a home computer, whereby it can be transferred to a provider. Others make use of high-bandwidth telephone or cable television lines for interactive video. The close monitoring afforded by these approaches may allow better health care through early detection of problems or more precise dosing of medications and biological agents, potentially reducing costs.

Office/hospital-based telemedicine services are usually real-time, clinician–patient interactions that conventionally would require face-to-face encounters between a patient and a health professional. Examples of office/hospital-based services that might be delivered by telemedicine include office visits, hospital visits, consultations and home visits, as well as a variety of specialized examinations and procedures.

Methods

To determine the key questions and guide the literature review, we developed an analytical framework as shown in Figure 1. We then formulated the key questions for each of the three study areas. For studies of diagnosis and management decisions and of clinical outcomes, the key questions determined whether the telemedicine system provided similar care, since telemedicine can be deemed efficacious when the quality of clinical care provided is at least as good as in-person care. For studies of access to care, we assessed whether the published studies provided evidence that telemedicine services resulted in measurable improvement of access.

The key questions from the analytical framework were:

A. Store-and-forward

1. Does store-and-forward telemedicine result in similar diagnostic decisions and recommendations for clinical management?
2. Does store-and-forward telemedicine result in similar health outcomes?
3. Does the availability of store-and-forward telemedicine services improve access to care?

B. Home-based

1. Does home-based telemedicine result in similar diagnostic decisions and recommendations for management?
2. Does the use of home-based telemedicine result in similar health outcomes?
3. Does the use of home-based telemedicine improve access to care?

C. Office/hospital-based

1. Does office/hospital-based telemedicine result in similar diagnosis and recommendations for management?

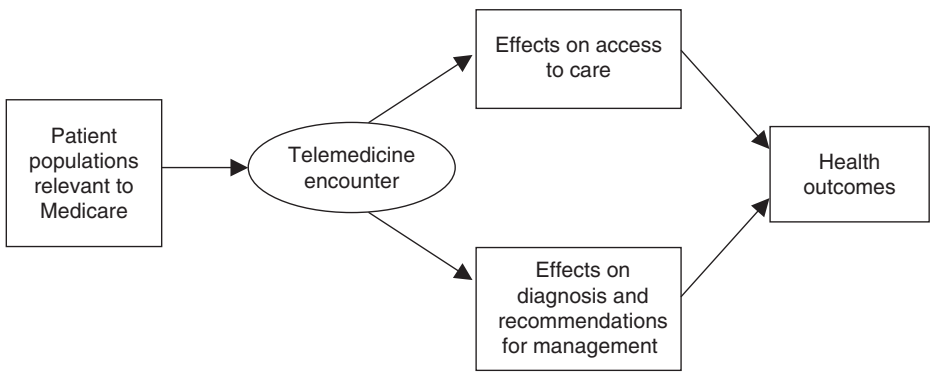


Figure 1 Analytical framework

2. Does office/hospital-based telemedicine result in similar health outcomes?
3. Does the availability of office/hospital-based telemedicine improve access to care?

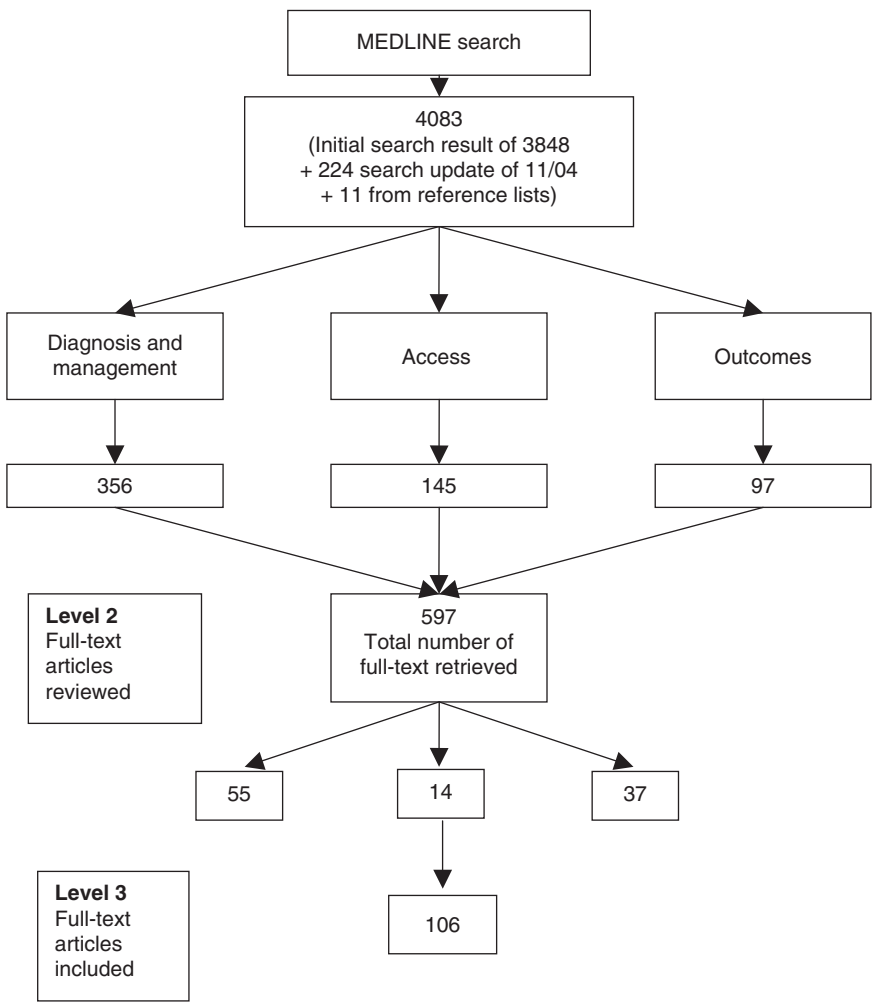
Literature search strategy

We searched the literature for reports about telemedicine programmes, activities and services. The search focused on English-language journal articles and reports pertaining to the three study areas. We identified programmes from the following sources:

1. Electronic bibliographic database. The search strategy was designed to find any publications about telemedicine and was used to search the MEDLINE database using Ovid, version 19.2.0. The key MeSH terms included *telemedicine*, *remote consultation*, *telecommunications* and *delivery of health care*. Appendix 1 lists the complete search string. The initial search identified telemedicine articles published between January 2000 and June 2004, resulting in 3848 citations. An update of the same strategy in November 2004 yielded 224 additional citations. Other databases, such as EMBASE and CINAHL, were not searched, since their coverage tends to duplicate that of MEDLINE for telemedicine.
2. Reference lists. Reference lists of previously published telemedicine systematic reviews were searched, resulting in the inclusion of 11 additional studies. Of these 11 studies, six were subsequently included following application of the inclusion criteria. Reference lists of included studies also were searched.

Selection of abstracts and full-text articles

The results of the literature search and selection of articles for inclusion are shown in Figure 2. All citations were entered into a database (EndNote).



Note: Articles may fit into more than one key question category

Figure 2 Results of literature search and abstract review

Four reviewers screened all citation titles and abstracts (if available) obtained from the citation acquisition. Each citation was reviewed by two of the four reviewers to make inclusion decisions for subsequent full-text review. The full-text articles were divided by key question and forwarded to the appropriate investigator for inclusion/exclusion assessment. Table 1 lists the inclusion and exclusion criteria for both the title/abstract level and the full-text level. The inclusion criteria were that the study be relevant to at least one of the three study areas; that it addressed at least one key question in the analytic framework for that study area and that it contained reported results (i.e. data). Exclusion criteria were that the study did not address a key question, addressed a key question but did not contain reported results or that the service did not require face-to-face encounters (i.e. radiology or pathology diagnosis). For the store-and-forward area, we included studies that used store-and-forward techniques as well as studies that used systems that could be easily adapted to store-and-forward. We excluded reports of telephone care programmes and equivalent programmes that used mail instead of the telephone, although programmes that used electronic mail as a substitute for face-to-face encounters were included. We also excluded studies of services that provided medical advice directly to the public.

Reliability of the inclusion/exclusion decisions was assessed by noting the percent agreement and κ values for each pair of reviewers (Table 2). Generally, agreement regarding inclusion or exclusion was high among the reviewers. We retrieved the full-text articles for citations selected for possible inclusion by either reviewer.

Table 1 Inclusion/exclusion criteria

Code	Explanation
Inclusion	
1	*Key question and data* Addresses a key question of one of the service areas and contains data (results)
Exclusion	
2	*No key question* Does not address a key question
3	*Key question, no data* Addresses a key question, but does not contain data
4	*Good background material and/or review* However, does not meet inclusion criteria
5	*Other* Indicate reason

Table 2 Inter-rater reliability

Reviewers	% agreement	κ value
WRH, SMS	90	0.56
WRH, TLD	92	0.59
DHH, SMS	86	0.40
DHH, TLD	91	0.42

Data abstraction

All studies rated as relevant on the basis of review of titles and abstracts were retrieved and distributed to one of the investigators. Studies judged to have evidence about a key question were then abstracted. For each key question, data from each study were abstracted using electronic abstraction forms and entered into an evidence table. A second investigator reviewed all studies included in the evidence tables to verify the evidence table content. The study quality ratings were assigned at this time (see below).

Assessment of study quality

We critically appraised the studies for each study area and key question. Studies that examined the effect of telemedicine activities on clinical outcomes or management were rated for quality according to the scale shown in Table 3.[4] The optimum design for studies of a diagnostic test is different from the optimum design for studies of therapies. For this reason, we used a separate scale to rate the quality of studies that compared the accuracy of telemedicine diagnoses to diagnoses made in conventional clinical encounters (Table 4). We also abstracted features of the study design that were likely to be associated with bias in studies of diagnostic test

Table 3 Classification of evidence for studies of clinical outcomes

Study class	Characteristics
I	Properly designed randomized controlled trials
II	Randomized controlled trials that contain design flaws preventing specification of Class I Properly designed trials with control groups not randomized Multicentre or population-based longitudinal (cohort) study Case–control studies
III	Descriptive studies (uncontrolled case series) Clinical experience Expert opinion Case reports

Table 4 Classification of evidence for diagnostic and management decisions

Study class	Characteristics
I	Case series of consecutive patients from relevant population of individuals who would use telemedicine; using an objective gold standard with blinded interpretation of results; with inter-observer analysis
II	Case series of patients from relevant population of individuals who would use telemedicine; using an objective gold standard
III	Case series not from relevant population or not using appropriate methodology for diagnostic test evaluation

performance.[5,6] We paid particular attention to known problems in telediagnosis studies, such as small sample sizes (less than 10–20 patients), selective application of definitive diagnosis testing and insufficiently long follow-up to determine diagnosis when a gold-standard test was not or could not be performed.

Telemedicine is commonly used to make diagnosis or management decisions, often by a specialist located remotely from the patient. Because many diagnostic decisions in medicine are presumptive rather than definitive, clinical assessments made by telemedicine can be evaluated on the basis of whether they are concordant as opposed to accurate. Measuring the accuracy of clinical assessments requires additional definitive testing, such as biopsies, which may not be performed in the course of routine clinical care. For this reason, we distinguished between concordance and accuracy in evaluating studies of clinical diagnoses. Accuracy is usually measured by comparison with a reference or gold standard.

In appraising studies addressing access to care, we adapted criteria described by the Institute of Medicine (IOM) as applied to the use of telemedicine.[7] The model of access to care incorporated three types of indicators: barriers (structural, financial and personal), utilization and outcomes (mortality, wellbeing or functionality). The IOM has recommended that studies of access to care measure both utilization and outcomes, and our criteria included both measures. Studies that examined only outcomes of care were assigned to the Outcomes category rather than to the Access category. The definition of access that we used had originally been proposed in a report by the IOM published in 1993[4] and had been widely disseminated prior to the period covered by the studies reviewed for the current report. Other models of access to care have been described,[8,9] but these models include elements of staff deployment and scheduling strategies that have rarely been addressed in studies of telemedicine. Thus, we found the IOM model to be best suited to the published literature in this domain.

Studies of access to care were rated for quality according to the scale shown in Table 5. Review of the studies of access in the original report[1] showed that the majority relied on utilization indicators alone. A few used indicators of reduced barriers to care. Most studies used models of access that included (1) increased opportunity to obtain a service locally and (2) reduced time for seeking and/or obtaining care.

Studies in all categories were also classified using a four-level scale that summarized the strength of the study's findings for direction of effect (Table 6). This classification system was modified from the system used in the original report[1] to reflect that the key questions require only that home-based telemedicine be not worse than conventional care. For those studies, the goal was to determine whether diagnostic and management decisions or clinical outcomes were similar, rather than determining the direction of an effect. Studies were classified as clearly similar when the confidence for measures of association was high and probably similar when those measures were lower. The difference in these definitions of direction of effect had a small effect on the classification of studies given a quality rating of I when comparing the findings of the original report and the present report.

Because of the larger evidence base for studies of diagnosis/management and clinical outcomes, we excluded Class III studies from the analysis in these categories. Class III studies were included in the evidence tables for access to care. We included tallies of Class III studies in all summary tables that show the number of studies and their class and effect for each specialty.

In assessing studies of diagnostic and management decisions, a Class I study had to include not only a comparison of the telemedicine and in-person decisions but also one of the following:

- in concordance studies, it included a comparison of a 'baseline' concordance between two or more face-to-face examiners
- in accuracy studies, it included measurement against a suitable 'gold standard' with measures such as sensitivity and specificity.

Therefore, when there was just a comparison of telemedicine and in-person concordance, the study was rated as Class II. Studies were also rated as Class II when the diagnostic assessment did not include a definitive gold standard consisting of an objective test (e.g. biopsy) or a commonly accepted clinical judgment (e.g. visual findings on gastrointestinal endoscopy or of diabetic retinopathy). Class III studies were excluded from our analysis of diagnosis and management decisions.

For the strength of evidence, a grade of A or B was given when the study set out to demonstrate similarity and did so. Class II studies were not graded higher than B, since studies with this level of methodology do not have the quality of evidence to provide convincingly strong results.

Table 5 Classification of strength of evidence for studies of access to care

Study class	Characteristics
I	Appropriate comparison group not exposed to telemedicine services; valid measures of utilization *and* outcomes
II	Appropriate comparison group not exposed to telemedicine services; valid measure of utilization
III	Comparison group absent or not comparable in some respects; valid measure of utilization; outcomes may also be measured

Table 6 Classification of direction of effect

A	Strong improvement or clearly comparable
B	Weak improvement or probably comparable
C	Conflicting evidence for improvement or comparability
D	Negative effect (evidence that technology does not provide comparability or improvement)

For outcomes studies, a Class I study had to be a randomized controlled trial (RCT). RCTs with clear and obvious flaws were rated as Class II, as were cohort, pre–post and observational studies. For the strength of evidence, a grade of A or B was given when the study set out to demonstrate similarity and did so, or when the study set out to show the superiority of telemedicine and did so. Class II studies of outcomes were also not graded higher than B.

Data synthesis

For the study areas with more than two studies, we constructed a summary table of specialties or domains and the strength of the evidence for each key question and type of telemedicine. The efficacy for telemedicine can therefore be gleaned from the number of studies that have a positive direction of effect, i.e. are rated A or B. For those procedures or services that have evidence, the summary tables show which analytical framework links are supported by evidence.

Results

As in the previous report, there were a large number of studies that met our inclusion criteria (Table 7), yet the methodology of many studies was weak (Table 8). Only a quarter of the studies met the criteria for Class I methodology, and even these had problems such as relatively small sample size and inadequate description of study details, such as concealment of allocation and other aspects of the randomization process. Some studies were included in more than one telemedicine study area.

Another problem with many of these studies concerns a statistical issue. As noted earlier, the goal of most telemedicine studies is only to show that telemedicine is similar to in-person care, not necessarily 'better' in some sense. This rationale is reasonable when there is other evidence that the telemedicine service is associated with decreased cost, increased convenience and/or improved access to care. One way to determine whether two approaches are similar is to show that there is no significant difference between them. However, lack of significance can also occur even when there is a difference, but the study lacks adequate statistical power to detect it. For this reason, studies with small sample sizes should compute, in addition to an α value (the well-known P value), the value of β. This value estimates the probability that a difference between two comparison groups truly exists when the study results fail to show a difference (also known as a type 2 error). Virtually none of the studies we reviewed reported β error. Thus, the 'statistical similarity' may exist because there was inadequate statistical power to show otherwise.

Store-and-forward telemedicine

Much as in our original report, the studies we found of store-and-forward telemedicine only assessed diagnosis or management decisions and access to care, but not clinical outcomes (Tables 9 and 10). As we also found in the original report, some aspects of the telemedicine systems in home and office–hospital settings made use of store-and-forward techniques, but in the context of larger and/

Table 7 Summary of included studies

	Present report				Original report			
Modality	**Diagnosis and management**	**Access**	**Outcomes**	**Total**	**Diagnosis and management**	**Access**	**Outcomes**	**Total**
Store-and-forward	32	5	0	37	22	2	0	24
Home-based	2	0	26	28	4	2	19	25
Office/hospital-based	21	9	11	41	33	7	6	46
Total	*55*	*14*	*37*	*106*	*59*	*11*	*25*	*95*

Table 8 Summary of studies by key questions and results

Summary by key question	**Total**	**I-A**	**I-B**	**I-C**	**II-B**	**II-C**	**II-D**	**III-B**	**III-C**
Diagnosis and management store-and-forward	32	2	3	2	23	2	0		
Diagnosis and management home-based	2	0	0	0	0	2	0		
Diagnosis and management office/hospital-based	21	1	3	1	14	2	0		
Diagnosis and management total	55	3	6	3	37	6	0		
Outcomes store-and-forward	0	0	0	0	0	0	0		
Outcomes home-based	26	5	2	0	18	0	0		
Outcomes office/hospital-based	11	3	0	0	7	1	0		
Outcomes total	37	8	2	0	25	1	0		
Access store-and-forward	5	0	1	0	1	0	0	2	1
Access home-based	0	0	0	0	0	0	0	0	0
Access office/hospital-based	9	0	1	1	3	1	0	3	1
Access total	14	0	2	1	4	1	0	5	2
All total	*106*	*11*	*10*	*4*	*66*	*8*	*0*	*5*	*2*

Table 9 Summary of studies of store-and-forward telemedicine for diagnosis and/or management decisions

Present	Total	I-A	I-B	I-C	II-B	II-C	II-D	III-B	III-C
Cardiology	1				1				
Dermatology	13		2		9	2			
Gastroenterology	2				2				
Gynaecology	3			2	1				
Ophthalmology	6	2	1		3				
Plastic surgery	7				7				
Total	*32*	*2*	*3*	*2*	*23*	*2*	*0*		
Original	**Total**	**I-A**	**I-B**	**I-C**	**II-B**	**II-C**	**II-D**	**III-B**	**III-C**
Ambulatory care	1					1			
Dentistry	1					1			
Dermatology	9		2		5			2	
Neonatology	1							1	
Ophthalmology	5				2	1	1	1	
Otolaryngology	2				1			1	
Wound care	1				1				
Total	*20*	*0*	*2*	*0*	*9*	*3*	*1*	*5*	

or interactive interventions. A summary of all studies by medical specialty is shown in Table 9, which also includes a tally of those from our original report. Studies graded A or B for effect indicate similarity of telemedicine and face-to-face approaches.

As we found in our original report, the largest number of studies came from the specialty of dermatology (Table 9). Of the 13 studies published since the last report, 10 assessed some aspect of concordance and four looked at accuracy. One study assessed aspects of both. Of the concordance studies, eight assessed diagnostic decisions and four assessed management decisions; two studies assessed both. Two of the diagnostic studies looked at some aspect of intra-observer concordance, while the remainder assessed inter-observer concordance.

The most commonly assessed aspect of teledermatology was inter-observer concordance.[10,11] The range of concordance varied widely, from 41–87% for complete agreement to 51–96% for disease-category agreement. Unfortunately, all of these studies were limited by the lack of measurement of concordance among more than one face-to-face examiner. In other words, none of the studies compared face-to-face vs. telemedicine agreement with face-to-face vs. face-to-face agreement. As such, none of the studies could be rated as Class I. In our previous report, two studies did assess concordance of face-to-face examiners.[12,13] Concordance studies assessing management decisions typically looked at decision to biopsy. While one study found complete agreement,[14] others found less concordance.[10,15,16] The studies of diagnostic accuracy typically compared the telemedicine diagnosis to some sort of gold standard, often a biopsy of a pigmented lesion.[10,17,23,26] Most of these studies did not calculate significance, but some did show a trend towards less accuracy for telemedicine.

Store-and-forward applications of teledermatology have generally used commonly available digital cameras and

Table 10 Studies of diagnosis and management for store-and-forward telemedicine

Source	Purpose	Sample	Number of telemedicine clinicians	Diagnosis or Management	Concordance	FTF vs. FTF concordance	Accuracy	Study class
Cardiology								
Dahl, 2002[61]	Accuracy of remote auscultation in children	Forty-seven patients, 20 with pathological murmurs, 20 with innocent murmurs and seven with no murmur	4	Diagnosis		No	Sensitivity=90%, Specificity=98%	II-B
Dermatology								
Barnard, 2000[10]	Diagnostic agreement in all patients; accuracy of diagnosis in those with definitive diagnostic test	Fifty cases, 25 confirmed by diagnosis testing	8	Both	For 50 cases, 77% (range 67–84%) for primary diagnosis and 90% (range 84–96%) for differential diagnosis; decision to biopsy 40% for FTF vs. 45% for TM	No	For 25 cases, 84% FTF vs. 73% TM; for eight cancers, 88% FTF vs. 90% TM	II-B
Coras, 2003[18]	Diagnostic agreement of teledermoscopy	A total of 100 cases of pigmented lesions using teledermatoscopy, 45% of which were biopsied	3	Diagnosis			For 45 cases, 91% FTF vs. 89% TM	I-B
DuMoulin, 2003[62]	Diagnostic agreement for TM	A total of 106 cases referred by general practitioner (GP)	1	Diagnosis	54% full agreement, 9% partial agreement (differential diagnosis) and 37% no agreement	No		II-C

Table 10 (Continued.)

Source	Purpose	Sample	Number of telemedicine clinicians	Diagnosis or Management	Concordance	FTF vs. FTF concordance	Accuracy	Study class
Eminovic, 2003[63]	Diagnostic agreement for patients seen via TM vs. FTF	Ninty-six cases referred by GP	12	Diagnosis	41% full agreement, 10% partial agreement (differential diagnosis) and 49% no agreement	No		II-C
Jolliffe, 2001, BJD[15]	Decision by GP to triage pigmented lesions for TM assessment	A total of 819 lesions assessed for referral	5	Management	For decision to refer, sens.=88% and spec.=66%; intra-observer κ=0.48	No		II-B
Jolliffe, 2001, CED[64]	Comparison of pigmented lesions diagnosed by TM vs. FTF	A total of 144 lesions assessed histologically	NS	Diagnosis			For 144 lesions, 43% FTF vs. 47% TM; no malignancies missed	I-B
Lim, 2001[65]	Diagnostic agreement for TM for primary and differential diagnosis	Fifty-three cases from 49 patients	4	Diagnosis	Self-concordance vs. FTF 88%; concordance for four other derms 79% (range 73–85%)	No		II-B
Oztas, 2003[66]	Diagnostic agreement for TM with pictures alone and clinical information added	A total of 125 patients referred	3	Diagnosis	Agreement of TM was 55–58% without clinical information, 69–87% with clinical information	No		II-B
Pak, 2003 (two studies)[16,67]	Intra-observer diagnostic agreement for TM	404 patients referred	1	Both	Intra-observer (TM followed by FTF) agreement was 70% complete, 21% partial and 9% none; for partial or no agreement, clinical significance was moderate 41% and severe 0.8%; biopsy rates false-positive 17% and false-negative 7%	No		II-B
Piccolo, 2002[17]	Diagnostic agreement with teledermoscopy	Forty-three cases of pigmented lesions	8	Diagnosis			91% FTF vs. 79–95% TM	II-B
Rashid, 2003[68]	Diagnostic agreement for TM	Twenty-six skin conditions in 33 patients	1	Diagnosis	81% agreement and 19% disagreement	No		II-B
Shapiro, 2004[14]	Decision to perform a skin biopsy by FTF dermatologist	Forty-nine patients with pigmented lesions	1	Management	100% agreement on decision to biopsy	No		II-B
Taylor, 2001[11]	Agreement for TM diagnosis and decision to make referral	A total of 194 patients assessed 13 months after actual visit	2	Diagnosis	Agreement of TM was 77%; no difference between intra- and inter-observer	No		II-B
Gastroenterology								
Kim, 2000[69]	Accuracy of GI endoscopy transmitted by video	Five patients for upper GI endoscopy, five patients for lower GI endoscopy – observed by TM	1	Diagnosis	100% agreement on all diagnoses but G–E junction not seen clearly on two upper GI endoscopies	No		II-B
Wildi, 2004[70]	Diagnostic quality of remote GI endoscopy	Fifty patients undergoing GI endoscopy	1	Diagnosis			For major lesions, sens.=98%, spec.=80%	II-B
Gynaecology								
Etherington, 2002[71]	Diagnostic agreement in telecolposcopy	Eighty-one women undergoing colopscopy	1	Diagnosis	For normal vs. abnormal, 91% agreement; for normal vs. low-grade CIN vs. high-grade CIN, 79% agreement	No		II-B

Table 10 (Continued.)

Source	Purpose	Sample	Number of telemedicine clinicians	Diagnosis or Management	Concordance	FTF vs. FTF concordance	Accuracy	Study class
Ferris, 2002[23]	Diagnostic agreement in telecolposcopy	A total of 186 women undergoing cervical biopsy after colposcopy (also interactive)	2	Both	Agreement for biopsy was 67% for site experts vs. interactive TM, 73% for local vs. site experts, 84% for local vs. interactive TM, and 73 for TM vs. S&F TM, comparable to decisions for endocervical curettage	Yes	Accuracy for local colposcopists 60%, local experts 53%, immediate TM 56%, later TM 50%	I-C
Ferris, 2002[22]	Sensitivity of telecolposcopy and remote cervicography	A total of 264 women undergoing cervical biopsy after colposcopy	3	Diagnosis			Accuracy with histology varied from 57% for local colopscopists to 52–56% for various types of TM	I-C
Ophthalmology								
Baker, 2004[20]	Accuracy of different levels of JPEG compression for findings and management decisions in diabetic retinopathy (DR)	Twenty diabetic patients with images compressed 55 × and 113 ×	1	Diagnosis	Agreement varied for retinal abnormalities from κ=0.45–1.0, for level of retinopathy from 0.73 to 1.0, and for management recommendation follow-up from 0.64 to 1.0	No		II-B
Ells, 2003[21]	Accuracy of diagnosing severe retinopathy of prematurity by images	Thirty-six premature infants	1	Diagnosis		No	Sensitivity=100% Specificity=96%	II-B
Gomez-Ulla, 2002[19]	Agreement in detection and grading of DR	A total of 126 eyes in 70 diabetic patients assessed for DR	1	Diagnosis			100% accuracy on diagnosis of DR, 94% accuracy for class of DR	I-A
Saari, 2004[72]	Agreement in grading DR	Seventy diabetic patients and controls assessed with various digital photography and hand-held digital video (DV) camera	3	Diagnosis			Sens./spec. best for red-free imaging (98/99%), worst for DV (7/50%)	I-A
Shiba, 2002[73]	Accuracy of fundus photography for DR	Sixty-one diabetic patients assessed with digital photography for DR	1	Diagnosis			Sens./spec. for best digital photography was 82/100%	I-B
Yogesan, 2000[74]	Agreement in TM screening	Forty-three subjects assessed with digital indirect ophthalmoscope (DIO) and hand-held fundus camera (HFC) vs. stereo fundus camera (gold standard)	1	Diagnosis	Correlation coefficient for DIO vs. gold standard was 0.80 and for HFC vs. gold standard 0.76	No		II-B
Wound care								
Braun, 2005[75]	Wound assessment using new generation mobile phone cameras	Sixty-one wounds in 52 patients	3	Diagnosis	Agreement vs. FTF varied from κ=0.74–0.82 for TM physicians	No		II-B
Gardner, 2001[76]	Accuracy of chronic wound assessments	Thirteen wound observations	1	Diagnosis	Agreement on eight characteristics was 75–100%, but only 54% on presence of epithelial tissue	No		II-B

Table 10 (Continued.)

Source	Purpose	Sample	Number of telemedicine clinicians	Diagnosis or Management	Concordance	FTF vs. FTF concordance	Accuracy	Study class
Halstead, 2003[77]	Management decisions in wound care for four yes/no decisions	Seventeen individuals with 20 wounds	1	Management	Agreement on management decisions averaged 89%	No		II-B
Houghton, 2000[78]	Correlation of wounds assessed by pressure sore status tool (PSST) and photographs	Assessment of photographic wound assessment tool (PWAT) in 137 skin ulcers	3	Diagnosis	Intra-rater correlation on PWAT score was 96% and inter-rater correlation was 73%	No		II-B
Jones, 2003[79]	Reliability of images to assess burn wounds	Sixty burn wounds assessed with different resolution digital photographs	1	Diagnosis	Intra-observer κ was 0.53–0.60	No		II-B
Jones, 2004[80]	Agreement of injury severity and operative priority in minor injuries requiring plastic surgery consultation	Eighty-two trauma referrals	3	Both	Correlation for grade of injury 0.78–0.81 and for operative priority 0.87–0.93	No		II-B
Kim, 2003[81]	Accuracy of chronic wound assessments	A total of 430 visits on 70 patients	NS	Diagnosis	Agreement for not healing was 67%, necrosis 77%, cellulitis 89%, osteomyelitis 73% and not closed 97%	No		II-B

CIN, cervical intraepithelial neoplasia; FTF, face-to-face; GI, gastrointestinal; sens., sensitivity; spec., specificity; S&F, store-and-forward; TM, telemedicine

varying techniques for storing and transmitting the digital photographs. Teledermoscopy is a technique by which a low-power lens is used to generate a magnified image of a discrete skin lesion. This methodology was tested in two studies of store-and-forward techniques and found to be comparable to face-to-face diagnosis of pigmented lesions.[17,18]

The second most frequently studied clinical area was wound care. Seven studies, all rated as Class II, demonstrated that some characteristics of skin wounds and ulcerations could be assessed effectively using store-and-forward telemedicine. However, most of these studies had a small number of patients and very small numbers of clinicians, raising the statistical power issues described above.

Six studies provide data on store-and-forward applications in ophthalmology. Four of these studies showed that a high accuracy of diagnosing diabetic retinopathy could be obtained.[19,20] Likewise, another investigation showed that severe retinopathy of prematurity could be assessed accurately.[21] One study found, however, that concordance was lower for severity of diabetic retinopathy and specific abnormalities.[20] Other specialties studied included cardiology, gynaecology and gastroenterology. The gynaecology studies assessing colposcopy were hindered by the limitations of that procedure even when done in person.[22,23] Table 10 provides a detailed analysis of these studies.

Five studies published in 2000–2004 reported evidence about the effect of store-and-forward techniques on access to care. The clinical domains of these five studies are summarized in Table 11, and details of the studies' designs and findings are provided in Table 12. The methodological quality of these studies was generally low. The studies of access provide information about how telemedicine systems have been used in real-world situations and thereby provide an estimate of the actual clinical effect of the systems. All of the studies measured utilization of traditional (non-telemedicine) clinical services following the telemedicine intervention, and all reported the proportion of patients for whom the telemedicine service was the only care received in the index clinical episode. However, two of the studies[24,25] collected no data to assess whether the care provided by the telemedicine service was adequate.

Table 11 Summary of studies of the effects of store-and-forward telemedicine on access to care

Present report	Total	I-B	II-B	III-B	III-C
Dermatology	2	1			1
Ophthalmology	1			1	
General surgery	1			1	
Multiple specialties	1		1		
Total	*5*	*1*	*1*	*2*	*1*
Original report	**Total**	**I-B**	**II-B**	**III-B**	**III-C**
Dermatology	2		1		1

Table 12 Studies of access for store-and-forward telemedicine

Source	Purpose/design	Intervention	Control	Measure of access	Population/sample	Results	Limitations	Study class
Whited, 2002[12]	Evaluate system for screening dermatology referrals in a Veteran's Administration (VA) medical centre Randomized trial of consecutive routine patient referrals	Digital image of skin lesion and standardized patient history	Text-based referral request	Time (in days) to definitive evaluation of skin problem	Primary care adult patients; mean age 61 years *n*=275	Median time was 41 days in teledermatology group and 127 days in control group. In all, 19% of teledermatology patients had definitive evaluation made by teledermatology	Dermatology clinic had a substantial appointment backlog that probably exaggerated the difference between groups	I-B
Mallett, 2003[27]	Evaluate teledermatology system for referrals from general practitioners Prospective case series of referrals to a community dermatology clinic	Referral letter and digital photographs submitted by email	None		Patients seen in offices of general practitioners in UK; age range 4 months–94 years *n*=325	A telediagnosis (based on the photographs and letter) in 48% of cases. Face-to-face appointments were made for 92% of patients, and 66% of patients were seen face-to-face. Of 99 patients for whom a telediagnosis was made, the face-to-face diagnosis was the same for 95%	Face-to-face diagnosis was not blinded to telediagnosis.	III-C
Lee, 2003[24]	Evaluate system for prescreening patients for surgery by a mobile surgical team Case series	Patient history, description of physical examination, laboratory results and digital photographs submitted to consultant surgeons in USA by email	None	Consulting surgeons' judgement of appropriateness of surgical therapy and actual completion of surgery by mobile surgical team	Adult patients referred for consideration of surgical therapy by local providers in Kenya *n*=44	35% of referred cases were judged appropriate for surgery; all of these patients underwent the planned surgery	Cases judged not to be surgical candidates by the email review were not re-evaluated face-to-face	III-B
Jaatinen, 2002[26]	Compare results of specialty consultations conducted by email between physicians or by conventional visits in specialty clinics Prospective randomized trial	Textual information provided by general practitioner using a Website. Consultant could ask for further information by email sent to the general practitioner (GP)	Appointment in specialty clinic	Location of further care provided after the consultation (local clinic vs. specialty clinic)	Adult patients (mean age 62 years) seen by GPs in single Finnish community; specialists located 15–95 km away *n*=72	In both the telemedicine and conventional groups, 25% of patients received follow-up care in local community	GPs could choose not to randomize patients if they preferred a face-to-face visit	II-B
Tennant, 2000[25]	Evaluate system for screening patients for diabetic retinopathy Case series	Stereoscopic digital retinal photographs of dilated eyes were obtained by a local ophthalmic photographer. Satellite link used to transmit images to urban centre to undergo review by retinal specialist	None	Follow-up care of screened patients	Patients with diabetes identified by GPs in remote Canadian community; mean age 55 years *n*=100	In total, 10% of patients were referred for laser photocoagulation	No information on prevalence of diabetes in the community or previous rates of screening	III-B

All of the studies that included data on access to care examined the use of store-and-forward telemedicine systems for screening patients referred for medical or surgical specialty services following referral by clinicians in primary care or general practice settings. One study[26] used only text information submitted by email, while the other four studies were based on the collection of digital photographs, usually to supplement conventional clinical information submitted in a text format. The effect on utilization of specialty services was generally modest. In the two studies of teledermatology, more than 80% of patients were recommended to have subsequent face-to-face evaluations by dermatologists.[12,27] In a randomized trial of all specialty consultation requests in a rural Finnish community, the email-based store-and-forward system had no effect on the proportion of patients who received follow-up care in the local community rather than at the regional centres providing specialty services.[26] The two other studies[24,25] used photography-based screening systems by which the majority of patients were recommended not to have specialty follow-up. However, these studies were of relatively low quality and did not collect any follow-up information on the screened patients.

The only study of access to care that was given a Class I rating evaluated a store-and-forward technique for screening primary care patients referred for dermatology consultation in a Veterans Affairs medical centre.[12] That study was a randomized trial that included a measure of the time to completion of the consultation. Dermatologists evaluating the patients randomized to teledermatology could determine the time interval to a face-to-face dermatology appointment, while patients randomized to the conventional care group had only a routine appointment scheduled. Patients randomized to the teledermatology group had significantly shorter time intervals until the face-to-face appointment. We judged this to be an unfair comparison, because the study design itself favoured improved access to care for the teledermatology group. Since it is likely that the hospital in which the study was conducted had a fixed number of appointment slots for the dermatology clinic, scheduling more rapid appointments for patients in the teledermatology group would tend to reduce the pool of available appointments and cause the appointments available to the patients randomized to the conventional care group to be, on average, even later. Thus, we found the study's primary conclusion to be inadequately supported by data. Nevertheless, this study did provide high-quality evidence about the effect of a store-and-forward technique on the rate of subsequent face-to-face assessments and the study found that telemedicine was associated with a low rate of obviating the need for subsequent in-person assessment by a dermatologist.

Home-based telemedicine

In contrast to store-and-forward telemedicine, although similar to our original report, most studies of home-based telemedicine evaluated the clinical outcomes of interventions (Table 13). Two studies did assess diagnostic capabilities in the home, finding various degrees of agreement and disagreement depending on the observation (Table 14). Most outcomes studies included patients with chronic diseases common in the Medicare population, such as congestive heart failure, diabetes mellitus, coronary artery disease and hypertension (Table 15).

A common characteristic of the studies of home-based telemedicine was that the intervention included dedicated staff (usually nursing staff) who monitored the data recorded in the home and developed clinical management plans. Some of the studies were RCTs that compared such systems (technology and dedicated staff) with conventional care (such as visiting nurse services). These studies found improved outcomes with the telemedicine-based interventions, but the design of the studies made it difficult to separate the benefit of the dedicated programme staff from that of the telemedicine intervention.

While a small number of the studies were well-designed RCTs,[28,29] the rest were limited by either small sample sizes and/or control groups of dubious value. In addition, while all of the studies found at least similar benefits in clinical outcomes, and thus obtained an effect rating of A or B, the value of such comparability (e.g. same but not better blood glucose control or weight loss) was not clear.

Three studies of chronic disease in the elderly showed the benefit of the dedicated programme in both patient

Table 13 Summary of studies of home-based telemedicine for clinical outcomes

	Total	I-A	I-B	I-C	II-B	II-C	II-D	III-B
Update								
Asthma	1				1			
Congestive heart failure	6	1	1		4			
Chronic disease	3	1			2			
Coronary artery disease	2	1			1			
Diabetes mellitus	5	1	1		3			
Hypertension	3	1			2			
Lung transplantation	1				1			
Multiple sclerosis	1				1			
Spinal cord injury	1	1						
Obesity	1				1			
Present								
Psychiatry	1				1			
Pulmonary medicine	1				1			
Total	*25*	*6*	*2*	*0*	*17*	*0*	*0*	
Original								
AIDS	2	1	1					
Alzheimer's	1		1					
Cardiology	1				1			
Chronic disease	3		1		1			1
Diabetes mellitus	10	1	1		8			
Hypertension	2	1	1					
Neonatology	1		1					
Pulmonary	1							1
Total	*21*	*3*	*6*	*0*	*10*	*0*	*0*	*2*

Table 14 Studies of diagnosis and management for home-based telemedicine

Source	Domain	Purpose	Sample	Number of TM clinicians	Diagnosis or management	Concordance	FTF vs. FTF concordance	Accuracy	Study class
Jenkins, 2001[82]	Congestive heart failure (CHF)	Agreement in findings of CHF patients by home health nurses	Twenty-eight home care patients with CHF	1	Diagnosis	Of 18 items assessed, TM more likely to claim nail colour abnormality and realtime nurse more likely to detect inspiratory wheeze, ankle oedema and pedal oedema	No		II-C
Morlion, 2002[83]	Pulmonary function testing (PFT)	Agreement between home and hospital spirometry after lung transplant	PFTs in 22 patients followed for an average of over 1 year	0	Diagnosis			Sens./positive predictive value for 'alarm' episodes were 63/39%	II-C

Table 15 Studies of health outcomes for home-based telemedicine

Source	Domain	Question	Study type	Control	Sample	Results	Limitations	Class
Artinian, 2003[34]	CHF	Does the medication compliance device Med-eMonitor improve care?	RCT	Nine patients with usual care	Nine patients with usual care plus compliance device and Web-based monitoring	No change in behaviours, walking endurance or functional class; improvement in quality of life for monitored group	Small sample size, short (3-month) follow-up	II-B
Benatar, 2003[28]	CHF	Does nurse telemanagement by advanced practice nurse and vital sign monitoring improve outcomes?	RCT	A total of 108 patients with nurse home visit	A total of 108 patients with transtelephonic home monitoring	Lower rate of hospital readmission and anxiety/depression; same Minnesota Living with Heart Failure Questionnaire and self-efficacy		I-A
de Lusignan, 2001[84]	CHF	Does home monitoring of vital signs and video consulting improve care?	RCT	Ten patients with usual care	Ten patients with home telemonitoring	Similar weight, blood pressure, and quality of life.	Small sample size.	II-B
Jerant, 2001[85]	CHF	Does home videoconferencing plus electronic auscultation improve care?	RCT	Twelve patients in usual care	Thirteen patients with telenursing care, 12 with usual plus telephone care	Both telephone and telecare had fewer emergency department visits and trends to fewer hospitalizations	Usual plus telephone care of equal efficacy	I-B

Table 15 (Continued.)

Source	Domain	Question	Study type	Control	Sample	Results	Limitations	Class
LaFramboise, 2003[86]	CHF	Does Health Buddy telecommunication device improve care?	RCT	Twenty-three patients with home visit, 26 with telephonic monotoring	Twenty-one patients with Health Buddy, 20 with HB+home visit	All groups improved self-efficacy and symptoms over time but no difference between modalities	Limited follow-up	II-B
Roth, 2004[87]	CHF	Does home monitoring of vital signs improve care?	Pre–post	A total of 118 patients before intervention	Same 118 patients after invention	Reduction in hospital days by two-thirds; near significant improvement in quality of life	Pre–post design means that factors other than telemedicine could have influenced outcome	II-B
Chumbler, 2004[88]	Chronic disease in elderly	Does Health Buddy, monitoring of vital signs and videoconferencing improve cognitive and other function?	Prospective case control	A total of 115 case-matched veterans referred from senior agencies or rehabilitation programmes	A total of 111 veterans enrolled in home telemonitoring project	Improvements in instrumental activities of daily living and functional independence measurement scales	No randomization, groups may have been different	II-B
Kobb, 2003[31]	Chronic disease in elderly	Does Health Buddy, monitoring of vital signs and videoconferencing improve cognitive and other function?	Cohort	A total of 1120 patients receiving usual care	A total of 281 patients receiving remote home care	Remote monitoring group had reduced hospital and nursing home admissions, ER and clinic visits	No randomization, groups may have been different	II-B
Noel, 2004[30]	Chronic disease in elderly	Does monitoring of vital signs directly into EHR improve quality of life and cognitive function?	RCT	Fifty-seven veterans	Forty-seven veterans	Statistically significant reduction in bed days of care, urgent visits, HbA_{1c} OARS cognitive status and functional level	Many other measures showed no difference	I-A
Ades, 2000[89]	Coronary artery disease	Does ECG and transtelephonic monitoring provide comparable outcomes for at-home cardiac rehabilitation?	Cohort	Fifty patients receiving usual care	Eighty-three patients	Exercise capacity, quality of life and complications (none) comparable in both groups	No randomization, groups may have been different	II-B
Barnarson, 2003[90]	Coronary artery disease	Does Health Buddy monitoring improve care?	RCT	Eighteen patients with Health Buddy asking series of questions	Seventeenpatients with routine care	Communication intervention group had higher self-efficacy, similar risk factor adherence and better functional outcomes by SF-36	Relatively small sample size	I-A
Bellazzi, 2003[36]	Diabetes mellitus	Does home glucose monitoring and videoconferencing improve outcomes?	Cohort	Sixty-seven users of diabetes telemedicine system	Sixty-two non-users of system	HbA_{1C} differences not significant but less variance in experimental group	No randomization, groups may have been different	II-B
Biermann, 2002[91]	Diabetes mellitus	Does home glucose monitoring improve outcomes?	RCT	Sixteen patients with conventional care	Twenty-seven patients with home glucose monitoring	Both groups had similar drops in HbA_{1C} levels.	Small sample size, un-explained uneven distribution into groups	II-B
Chase, 2003[37]	Diabetes mellitus	Efficacy of home monitoring of blood glucose	RCT	Thirty-three patients receiving usual monitoring	Thirty patients receiving home monitoring	No difference in HbA_{1c} or hypoglycaemic events (although lower costs for experimental group)		I-B

Table 15 (Continued.)

Source	Domain	Question	Study type	Control	Sample	Results	Limitations	Class
Izquierdo, 2003[92]	Diabetes mellitus	Does diabetes education delivered by telemedicine improve outcomes?	RCT	Twenty-two patients with education delivered in-person	Twenty-four patients with education delivered via telemedicine	No change in HbA_{1C} or behaviour goals between groups		
Welch, 2003[93]	Diabetes mellitus	Does home glucose monitoring improve outcomes?	RCT	Twenty-six patients who used modem-equipped glucometers	Twenty-sixpatients who received usual care	Slightly larger drop in HbA_{1C} for experimental group but not significant	Results obtained from Montori paper, over half of subjects lost to follow-up at 12 months	
Montori, 2004[94]	Diabetes mellitus	Does home glucose monitoring with feedback improve outcomes?	RCT	Sixteen patients with glucometer transmission plus nurse feedback	Fifteen patients with glucometer transmission but no feedback	Significant reduction in HbA_{1C} (8.2 vs. 7.8%), 50 more minutes per patient in telephone time for experimental group		
Artinian, 2001[95]	Hypertension	Does home monitoring and community-based monitoring of blood pressure improve care?	RCT	Nine patients with usual care	Six patients with home telemonitoring and six with community-based monitoring	Drop in blood pressure for both experimental groups statistically significant over control group	Small sample size, short (3-month) follow-up	
Bondmass, 2000[96]	Hypertension	Does home monitoring of blood pressure improve care?	Pre-post	33 patients with uncontrolled hypertension >1 year	Same 33 patients after invention	Significant reduction in blood pressure from average of 154/90 to 141/83 mmHg	Pre-post design means that factors other than telemedicine could have influenced outcome	
Rogers, 2001[33]	Hypertension	Does home monitoring of blood pressure improve care?	RCT	Fifty-five patients with usual care	Fifty-six patients with home telemonitoring	Better improvement in mean, systolic and diastolic pressure (mmHg) for home telemedicine (−2.8) vs. control (+1.3)	Clinical significance of improvements in blood pressure not clear	I-A
Mullan, 2003[97]	Lung transplantation	Does monitoring by home electronic symptom diary improve outcomes in patients awaiting lung transplant?	RCT	Fifty-two patients with telephone reporting	Sixty-seven patients uploading electronic diary	Adherence, length of stay in hospital after transplant and survival after transplant identical	Few clinical variables assessed	II-B
Egner, 2003[98]	Multiple sclerosis	Does telerehabilitation programme delivered via video or telephone improve care?	RCT (subgroup analysis)	Seven patients with in-person and 11 patients with telephone rehabilitation	Nine patients with video rehabilitation	Generally equivalent scores over two years on quality of well-being (QWB) scale, Center for Epidemiologic Studies Depression (CES-D) scale and Fatigue Severity Scale (FSS)	Subgroup analysis of larger RCT, small sample size	II-B
Phillips, 2001[99]	Newly injured spinal cord patients	Does video-based rehabilitation improve care?	RCT	Thirty-nine patients with standard intervention, 36 with telephone intervention	Thirty-six patients with video intervention	Video intervention group had significantly higher QWB scale at one year and reduced annual hospital days		I-A
Harvey-Berino, 2002[100]	Obesity	Does a therapist-led Internet support group lead to better weight loss?	RCT	Fifteen patients in control group, 14 patients in therapist-led in-person group	Fifteen patients in therapist-led Internet group	Amount of weight loss similar in all groups	Small sample size	II-B

Table 15 (Continued.)

Source	Domain	Question	Study type	Control	Sample	Results	Limitations	Class
Chan, 2003[101]	Paediatric asthma	Efficacy of store-and-forward home video monitoring of inhaler use along with educational Website and adherence monitoring	RCT	Five patients given office-based education	Five patients given home unit for video monitoring and education	Small non-significant benefits for telemedicine group, with exception of significantly improved peak flow values between 91 and 180 days	Very small sample sizes and differences among them	II-B
D'Souza, 2002[102]	Psychiatry	Does a psycho-educational programme by videoconference after inpatient discharge improve care?	Cohort	Twenty-seven patients discharged to conventional care	Twenty-four patients discharged to care plus programme	Telemedicine patients had higher adherence, lower readmission and lower medication side effects	No randomization, groups may have been different	II-B
Maiolo, 2003[103]	Pulmonary disease	Does home monitoring of pulmonary status improve care?	Pre–post	Twenty-three patients with home monitoring of pulmonary function	Same patients after intervention	Significant reduction in hospital admissions (2.0 vs. 1.0) and acute exacerbations (1.4 vs. 0.63)	Pre–post design means factors other than telemedicine could have influenced outcome	II-B

HbA_{1C}, haemoglobin A_{1C}; SR-36, short form-36

functional status and reduced emergency department visits and hospital admissions.[30,31] Some interventions tailored for specific diseases were found to be effective in asthma,[32] congestive heart failure (CHF), hypertension and pulmonary disease.[28,33–35] Other home-based interventions, such as blood glucose measurements intended to improve management of diabetes mellitus, were not found to be better than usual care.[36,37] Interventions in other domains, such as obesity[38] and lung transplantation,[39] also failed to show benefit over usual care.

While two studies were identified in the original report that examined the effect of home-based telemedicine systems on access to care, no studies were identified in the 2000–2004 period. Home-based systems have nearly always been used to enhance the care of patients who already receive conventional clinical services, either through clinic visits or via home-care agencies. The primary rationale for home-based telemedicine is to improve data collection and/or communication rather than to supplant conventional care (such as clinic or home visits). Thus, the lack of studies examining conventional measures of access to care is not surprising.

Office/hospital-based telemedicine

Studies of office/hospital-based telemedicine provide evidence about diagnosis and management decisions (Tables 16 and 17), clinical outcomes (Tables 18 and 19) and access to care (Tables 20 and 21). For diagnosis and

Table 16 Summary of studies of office/hospital-based telemedicine for diagnosis and/or management decisions

	Total	I-A	I-B	I-C	II-B	II-C	II-D	III-B	III-C
Present									
Cardiology	2				2				
Dermatology	1				1				
Gastroenterology	1				1				
Neurology	4				4				
Ophthalmology	6		1	1	2	2			
Otolaryngology	2		1		1				
Psychiatry	3	1			2				
Rheumatology	1		1						
Vascular surgery	1				1				
Total	*20*	*1*	*3*	*1*	*13*	*2*	*0*	*0*	*0*
Original									
Cardiology	5		1		3				1
Dentistry	1								1
Dermatology	7					2			5
Emergency medicine	3				3				
Neurology	2		1		1				
Ophthalmology	2					1		1	
Otolaryngology	2				1			1	
Psychiatry	7		2		5				
Pulmonary	1				1				
Rheumatology	1						1		
Trauma	1				1				
Urology	1								1
Total	*33*	*0*	*4*	*0*	*15*	*3*	*1*	*2*	*8*

Table 17 Studies of diagnosis and management for office/hospital-based telemedicine (NS=not stated)

Source	Specialty	Purpose	Sample	Number of telemedicine clinicians	Diagnosis or management	Concordance	FTF vs. FTF concordance	Accuracy	Study class
Scalvini, 2002[104]	Cardiology	Remote diagnosis of chest pain by GP	A total of 952 ECG diagnoses made by TM	NS	Diagnosis			Sens./spec. of service was 97/90%	I-B
Terkelsen, 2002[105]	Cardiology	Prehospital diagnosis in ambulances	A total of 250 patients for pre-hospital diagnosis of acute myocardial infarction	NS	Diagnosis			Sens./PPV for acute myocardial infarction was 88/56%	I-B
Nordal, 2001[106]	Dermatology	Agreement in diagnosis via videoconference	A total of 121 patients referred to dermatologist	2	Diagnosis	Agreement was 72% complete and 14% partial	No		II-B
Craig, 2000, EJN[107]	Neurology	Agreement of neurological inpatient assessment	Twenty-five neurology inpatients	1	Diagnosis			Of 25, 23 diagnoses correct by interactive videoconferencing	II-B
Craig, 2000[107]	Neurology	Agreement of neurological outpatient assessment	Twenty-five neurology outpatients	1	Diagnosis			In all, 24 or 25 diagnoses correct by interactive videoconferencing	II-B
Handschu, 2003[108]	Neurology	Agreement of stroke assessment via NIH Stroke Scale	Forty-one patients receiving NIH Stroke Scale in setting of acute stroke	NS	Diagnosis	Agreement on 13 elements varied from 0.44 to 0.89 on unweighted κ and from 0.85 to 0.99 when weighted according to accepted protocol	No		II-B
Wang, 2003[109]	Neurology	Accuracy of stroke assessment using NIH Stroke Scale	Twenty patients receiving NIH Stroke Scale in setting of acute stroke	4	Diagnosis	Correlation of score for TM vs. FTF was 0.96	No		II-B
Bowman, 2003[110]	Ophthalmology	Accuracy of eye injury assessment	Eighty patients with eye injury (40 each for TM vs. FTF and FTF vs. FTF)	2	Diagnosis	For TM vs. FTF, agreement was complete 58%, partial 37% and not 5%. For FTF vs. FTF, agreement was complete 75%, partial 20% and not 5%. Agreement better when slit lamp vs. ophthalmoscope was used	Yes		
Cheung, 1999[111]	Ophthalmology	Diagnostic agreement in strabismus patients by category, angle of deviation and ocular muscle action	Forty-two patients remotely and 43 patients in person	1	Diagnosis	Agreement good on horizontal category (κ=0.66–0.74), but poor on vertical category (κ=0.25–0.28). κ otherwise good for angle of deviation and most ocular muscle action but significant increased odds of disagreement for telemedicine vs. in-person comparison	No		

Table 17 (Continued.)

Source	Specialty	Purpose	Sample	Number of telemedicine clinicians	Diagnosis or management	Concordance	FTF vs. FTF concordance	Accuracy	Study class
Crowston, 2004[112]	Ophthalmology	Measurements in trabeculectomized eyes using telemedicine vs. in-person	Forty trabeculectomized eyes in 40 patients	3	Diagnosis	For six measures, agreement always higher in FTF vs. FTF than TM vs. FTF	Yes		I-C
Dawson, 2002[113]	Ophthalmology	Assessment of strabismus	Thirty patients with strabismus	2	Diagnosis	Agreement was complete 80%, partial 3% and incomplete 17%	No		II-B
Rayner, 2001[114]	Ophthalmology	Agreement of ophthalmic adnexal examination	Seventeen patients with adnexal (eye) conditions	2	Both	58% had full agreement, 24% had diagnostic agreement but management disagreement and 18% had incorrect TM diagnosis	No		II-C
Smith, 2003[115]	Ophthalmology	Slit lamp assessment via telemedicine	Twelve cataract and 10 control patients	2	Both	Agreement was 70–100% for control patients and 0–100% for cataract patients	No		II-C
Givens, 2003[116]	Otolaryngology	Agreement in audiometry testing	Forty-five patients assessed with conventional and TM audiometer for air conduction, 25 of whom were also assessed for bone conduction	NA	Diagnosis	Correlation was 0.71–0.89 for different frequencies in air conduction, 0.79–0.94 for bone conduction	NA		I-B
Ullah, 2002[117]	Otolaryngology	Accuracy of otolarynology consultation	Intra-observer concordance for assessment of 42 patients	1	Diagnosis			For first 20 patients, diagnosis incorrect in eight; for next 22 patients, all diagnoses correct	II-B
Menon, 2001[118]	Psychiatry	Psychiatric assessment of depression and cognitive status using videophone	Administration of GDS, HAM-D and SPMSE to 24 elderly patients	2	Diagnosis	Coefficient of variation for GDS was 21% FTF/28% TM (NS), for HAM-D was 28% FTF/31% TM (NS), and for SPMSE was 63% FTF/32% TM (P=0.02)	No		II-B
Shores, 2004[119]	Psychiatry	Neuropsychiatric evaluation via telemedicine	Sixteen patients screening positive for dementia on 7-min screen	NS	Diagnosis	100% agreement on presence of dementia (in 12 patients)	No		II-B
Yoshino, 2001[120]	Psychiatry	Agreement in Brief Psychiatric Rating Scale administration	Forty-two patients with chronic schizophrenia interviewed by FTF and viewed by narrowband and broadband TM	NS	Diagnosis	Agreement was 87% FTF vs. FTF, 88% FTF vs. broadband TM, 44% FTF vs. narrowband TM ($P<0.05$)	Yes		I-A

Table 17 (Continued.)

Source	Specialty	Purpose	Sample	Number of telemedicine clinicians	Diagnosis or management	Concordance	FTF vs. FTF concordance	Accuracy	Study class
Leggett, 2001[121]	Rheumatology	Accuracy of rheumatology consultation	A total of 100 patients referred to a rheumatologist	1	Diagnosis			Accuracy of diagnosis was 97% for TM, 71% for telephone	I-B
Endean, 2001[122]	Vascular surgery	Agreement of treatment recommendations for vascular surgery patients seen via telemedicine	Sixty-four vascular abnormalities in 32 patients	1	Management	Agreement with treatment recommendations was 91%	No		II-B

GDS, Geriatric Depression Scale; HAM-D, Hamilton Depression Rating Scale; PPV, positive predictive value; SPMSE, Short Portable Mental Status Exam

Table 18 Summary of studies of office/hospital-based telemedicine for clinical outcomes

	Total	I-A	I-B	I-C	II-B	II-C	II-D	III-B
Present								
Critical care	1				1			
Neurology	1					1		
Orthopaedics	2				2			
Otolaryngology	1	1						
Psychiatry	3	1			2			
Wound care	1				1			
Total	*9*	*2*	*0*	*0*	*6*	*1*	*0*	
Original								
Dermatology	1				1			
Emergency medicine	1	1						
Intensive care	1				1			
Neonatology	1				1			
Neurosurgery	2							2
Total	*6*	*1*	*0*	*0*	*3*	*0*	*0*	*2*

management decisions, the most commonly studied specialty was ophthalmology. As with store-and-forward studies, some aspects of ophthalmology evaluation were amenable to interactive telemedicine, while others were not. One Class I study showed rates of disagreement in eye injuries under 10%,[40] while another found that disagreement was consistently higher with telemedicine than when comparing two in-person evaluations.[41]

Other frequently studied specialties included neurology and psychiatry. Although the studies were rated Class II, two studies showed that neurological diagnosis was highly concordant[42,43] and two studies showed that the National Institutes of Health (NIH) Stroke Scale could be reliably administered via telemedicine.[44,45] A few Class II studies demonstrated concordance on a variety of psychiatric scales.[46,47,17] Studies in other specialties, such as dermatology,[48] rheumatology[49] and vascular surgery,[50] demonstrated that some diagnostic assessments can be successfully administered interactively via telemedicine.

Studies of clinical outcomes also showed that for most of the clinical specialties assessed, outcomes between conventional and telemedicine interventions were similar. However, most of these studies were limited by small sample sizes (with the caveats concerning significance described earlier), lack of randomization and assessment of less than the full range of clinical outcomes. None of these studies had sufficient statistical power to avoid β error. Class I RCTs showing similar outcomes were conducted in otolaryngology[51] and psychiatry.[52,53]

The studies of access examined the use of office-based telemedicine in both suburban and rural settings, and examined both specialist evaluations and follow-up continuity care. In limited studies of patients with sickle cell anaemia[54] and patients with chronic psychiatric disorders,[55] office-based telemedicine appeared to be adequate for the routine care of patients in rural areas, with few problems reported. For new evaluations by specialists of patients referred by general practitioners (GPs), the use of office-based telemedicine led to a

Table 19 Studies of health outcomes for office/hospital-based telemedicine

Source	Specialty	Question	Study type	Control	Sample	Results	Limitations	Study class
Breslow, 2004[123]	Critical care	Does supplemental remote intensive care unit (ICU) monitoring improve outcomes of care?	Pre–post	A total of 1396 patients before telemedicine intervention	A total of 744 patients after intervention	Telemedicine reduced mortality (relative ratio (RR)=0.73), length of stay (3.6 vs. 4.4 days) and variable costs per case	Pre–post design means factors other than telemedicine could have influenced the outcome	II-B
Marcin, 2004[124]	Intensive care	Can remote ICU telemedicine result in similar outcomes?	Cohort	A total of 180 patients in rural hospitals	Forty-seven patients who had telemedicine	Similar severity-adjusted death rate	No randomization	II-B
Chua, 2001[125]	Neurology	Are new neurological referrals as effective via telemedicine as in-person as measured by number of tests, prescriptions, and disposition?	RCT	Rate of agreement of telemedicine vs. in-person	A total of 76 patients evaluated by telemedicine, 65 patients evaluated by in-person care	In-person patients had fewer neurological (6/82 vs. 26/86) and non-neurological (5/82 vs. 20/86) tests but same amount of prescriptions and discharge after first consultation	Focus mainly on process and not clinical outcomes	II-C
Russell, 2003[126]	Orthopaedics	Does telerehabilitation for total knee replacement have similar outcomes?	RCT	Eleven patients randomized to conventional care	Ten patients who had weekly treatment for 6 weeks	No difference in physical or functional measurements	Small sample, short follow-up	II-B
Vuolio, 2003[127]	Orthopaedics	Is videoconferencing aided by GP and nurse as effective as traditional clinic?	RCT	A total of 69 patients seen in outpatient clinic	A total of 76 patients seen in health centre by videoconference	Equal fulfillment of patient management plans	Focus mainly on process and not clinical outcomes	II-B
Mashima, 2003[128]	Otolarngology	Can voice therapy be delivered as effectively by telemedicine as in person?	RCT	Twenty-eight patients with conventional voice therapy	Twenty-three patients with videoconference voice therapy	Both groups improved, with no differences between them		I-A
Bouchard, 2004[129]	Psychiatry	Can cognitive-behaviour therapy for panic disorder be delivered via telemedicine?	Cohort	Eleven patients with videoconferencing	Ten patients with face-to-face care	Both groups had similar improvement in reduction in panic attacks and scores on Beck Depression Inventory	Small sample, no randomization	II-B
Kennedy, 2003[130]	Psychiatry	Do patients using telepsychiatry have similar health outcomes to in-person care?	Cohort	A total of 92 patients who did not have telepsychiatry	A total of 32 patients who had telepsychiatry	No difference in Health of the Nation Outcome Scale or Mental Health Inventory	No randomization, probable differences between experimental and control groups	II-B

Table 19 (Continued.)

Source	Specialty	Question	Study type	Control	Sample	Results	Limitations	Study class
Nelson, 2003[131]	Psychiatry	Can childhood depression be treated comparably by videoconferencing?	RCT	Fourteen patients receiving usual care	Fourteen patients receiving telepsychiatry	Similar improvement on Children's Depression Inventory		I-A
Ruskin, 2004[132]	Psychiatry	Is telepsychiatry treatment (medications, education, brief supportive counseling) similar to face-to-face treatment?	RCT	Sixty patients treated with face-to-face treatment	Fifty-nine patients treated with telepsychiatry	Equal outcomes in both groups for Hamiltion Depression Rating Scale and Beck Depression Inventory		I-A
Wilbright, 2004[133]	Wound care	Is telemedicine treatment similar to in-person treatment?	Cohort	A total of 120 patients treated conventionally	Twenty patients treated via interactive telemedicine	No differences in healing time or % healed	No randomization, probable differences between experimental and control groups	II-B

Table 20 Summary of studies of the effect of office/hospital-based telemedicine on access to care

	Total	I-B	I-C	II-B	II-C	III-B
Present						
Neurology	2				1	1
Orthopedics/rheumatology	3	1		1		1
Ophthalmology	1					1
Multiple specialties	1		1			
Psychiatry	1			1		
Haematology	1			1		
Total	*9*	*1*	*1*	*3*	*1*	*3*
Original						
Neurosurgery	3			2		1
Cardiology	2					2
Multiple specialties	2					2
Total	*7*	*0*	*0*	*2*	*0*	*5*

significantly greater rate of diagnostic test utilization than face-to-face consultations for neurology patients[56] but not for patients needing other types of specialty care.[57,58] Two studies compared office-based telemedicine to telephone consultations between a referring physician and a specialist.[49,59] Both of these studies had weak designs but had results suggesting that the telemedicine system provided faster access to definitive care.

Discussion

Evidence about efficacy

The findings of the present report are similar to those of our previous report: there are still serious gaps in the evidence base for telemedicine. This situation is hardly unique to telemedicine. The best evidence for the effectiveness of telemedicine is in medical specialties for which verbal interactions are a key component of the patient assessment, such as psychiatry and neurology. (Note that teleradiology was excluded from the present analysis. As noted above, we focused on telemedicine that was a substitute for face-to-face care.) Various psychiatric and neurological assessments can be administered effectively via videoconferencing. Likewise, treatments administered in these specialties via telemedicine appear to achieve similar results to face-to-face care. It can be concluded that medical care administered via videoconferencing can achieve results that are comparable to their in-person counterparts.

Our systematic review also identified several studies, a few of them of high methodological quality, showing the benefits of home-based telemedicine interventions in chronic diseases. These systems appear to enhance communication with health-care providers and provide closer monitoring of general health, but the studies of these techniques were conducted in settings that required additional resources and dedicated staff. Deployment of home monitoring technology in the absence of these

Table 21 Studies of access for office/hospital-based telemedicine

Source	Purpose/design	Intervention	Control	Measure of access	Population/sample	Results	Limitations	Study class
LaMonte, 2003[134]	Evaluate system for screening patients with symptoms of stroke seen in emergency department 100 miles from stroke treatment centre Comparison of telemedicine cases to concurrent cases managed by telephone consultation	Two-way audio-video link; consultant neurologist interviews and examines stroke patient by telemedicine	Telephone discussion between emergency department physician and consultant neurologist	% of patients receiving fibrinolytic therapy for acute stroke	Patients presenting to hospital emergency department; no demographic data reported. *n*=50	22% of 23 telemedicine patients received fibrinolytic therapy, compared with 4% of 27 traditional consultations	An undetermined number of the control group patients were ineligible for fibrinolytic therapy	III-B
Woods, 2000[135]	Evaluate system for providing follow-up care to patients with sickle cell anaemia living more than 100 miles from university clinic Before/after study of clinic workload	Two-way audio-video link; consultant at university clinic interviews patient; on-site nurse assists with physical examination	Rural outreach clinics; consultant travels to clinic for face-to-face patient encounters	Annual number of patient encounters at rural sites	Adult patients with sickle cell anaemia; 84% Medicaid insurance *n*=128 in post-telemedicine period	A total of 271 annual clinic visits in pre-telemedicine period (1996); 745 clinic visits in post-telemedicine period (1999)	Outreach clinics continued during telemedicine period. Of the 745 visits in 1999, 466 were by telemedicine and 279 were conventional outreach clinic visits. An additional staff member (physician assistant) was added in 1999	II-B
Haukipuro, 2000[136]	Evaluate satisfaction with a system for routine orthopaedic clinic visits Randomized trial of patients referred to a university orthopaedic clinic in Finland	Two-way audio-video link; orthopaedic specialist at university clinic interviews patient; primary care physician assists with physical examination at remote site	Patient travels to university clinic for face-to-face encounter	Overall satisfaction of clinical quality of examination by orthopaedic specialist	Orthopaedic patients; mean age 57 years. *n*=145	Overall satisfaction rated as very good or good in 80% of telemedicine encounters and 89% of conventional encounters	No measures of clinical outcomes	II-B
Vuolio, 2003[127]	Evaluate treatment plans of newly referred orthopaedic patients examined via a telemedicine system Randomized trial of patients referred to a university orthopaedic clinic in Finland	Two-way audio-video link; orthopaedic specialist at university clinic interviews patient; primary care physician assists with physical examination at remote site	Patient travels to university clinic for face-to-face encounter	Classification of management plans formulated by physician conducting the patient evaluation	Orthopaedic patients; mean age 56.7 years (same study subjects as reported in Haukipuro 2000) *n*=145	Management plans (including rates of planned surgical procedures) were similar in the two groups	No measures of actual clinical outcomes	I-B
Wallace, 2002[137]	Measure whether a telemedicine system to conduct initial specialist evaluations	Two-way audio-video link; both GP and specialist participate	Face-to-face encounter between patient and specialist	Orders for follow-up face-to-face appointments and diagnostic tests	Patients seen in offices of GPs in UK; mean age 48 years *n*=1939	52% of telemedicine patients and 41% of control group patients were offered follow-up appointments. Follow-up	No measures of actual clinical outcomes	I-C

Table 21 (Continued.)

Source	Purpose/design	Intervention	Control	Measure of access	Population/sample	Results	Limitations	Study class
	reduces rates of diagnostic test utilization and subsequent face-to-face encounters Randomized trial of patients referred by GPs to specialists in London, UK	in teleconference with patient				appointment rates were higher for surgical specialty consultations than for medical specialty consultations. Telemedicine patients had fewer tests ordered		
Leggett, 2001[121]	Compare telephone-based consultation to video-based methods for providing rheumatology consultations Comparison of successive telephone and video-based consultations on same patients	Patient interview by rheumatologist using desktop videoconferencing system	Telephone conversation between GP and rheumatologist	Physician's opinion of need to see patient face-to-face following teleconsultation	Convenience sample of patients referred to a rheumatologist; mean age 48 years *n*=100	Rheumatologist judged that 75% of patients needed to be seen following the telephone consultation but only 6% following the videoconference	Only one rheumatologist studied; telephone and videoconference sessions were not blinded	III-B
Kennedy, 2003[130]	Compare psychiatric consultations delivered by videoconferencing to care of similar patients delivered face-to-face Non-randomized prospective control-group design	Interview conducted by videoconferencing equipment	Conventional evaluations in psychiatry clinic	Mental health scales completed by clinician and patient at baseline and 12 months after initial evaluation	Australian adults referred by GP for psychiatric consultation *n*=124	Mean scores of the mental health scales improved over 12 months. No difference between groups in the mean size of the change scores	Telepsychiatry patients had a higher rate of anxiety disorders, and conventional care patients had a higher rate of psychotic disorders	II-B
Chua, 2002[138]	Compare management plans of patients undergoing neurological evaluation by videoconference or by face-to-face evaluation Prospective randomized trial of newly referred patients. Additional non-randomized comparison of four other patient cohorts	Consulting neurologist interviewed patient and reviewed radiology images placed on viewing box at telemedicine site. Physical examination conducted by assistant at the telemedicine site	Conventional clinic visits staffed by neurologists or GP	% of patients receiving appointments for further testing or follow-up appointments	Adult patients presenting to GPs with neurological complaints (mean age 35 years) Randomized trial: *n*=141; additional comparison groups: *n*=252	In the randomized trial, neurologists seeing patients face-to-face ordered tests for significantly fewer patients and showed no difference in the rate of follow-up appointments, when compared to the teleconsultation group. The non-randomized patients seen face-to-face by neurologists had similar rates of tests and follow-up appointments as the teleconsultation patients. The non-randomized patients seen face-to-face by GPs had significantly higher rates of tests and follow-up appointments when	Similarity of patients seen by GPs was not well described	II-C

Table 21 (Continued.)

Source	Purpose/design	Intervention	Control	Measure of access	Population/sample	Results	Limitations	Study class
						compared to the teleconsultation patients		
Taylor, 2003[139]	Evaluate teleconsultation of South African patients having eye disease by British ophthalmologists Case series	Local clinicians used a video slit lamp and presented case information by videoconferencing equipment	None	Judgement of consensus panel of ophthalmologists who conducted retrospective case reviews	Patients seen in eye department of single South African hospital. Average age=26 years (range 2–70) *n*=90	Teleconsultation judged to have definite effect on diagnosis in 24% and possible effect in 22%. Teleconsultation judged to have definitely improved visual health in 10% and possibly improved visual health in 53% of cases	Limited follow-up information on cases	III-B

integrated systems is unlikely to be beneficial. Systems designed to facilitate specific aspects of care, such as blood glucose and blood pressure measurements, provide less clear benefit.

The specialty with the largest number of studies is dermatology, and most studies of teledermatology have evaluated store-and-forward techniques. The body of evidence summarized in the present report is consistent with the findings of our earlier report. There continue to be highly variable rates of inter-observer and intra-observer agreement in diagnoses. This issue can only be resolved by high-quality studies that compare not only the concordance of telemedicine vs. face-to-face diagnosis but also the concordance of face-to-face vs. face-to-face diagnosis in the same situation. It should be noted that this has been done in most of the tele-ophthalmology diagnostic concordance studies.

The published studies of teledermatology have other flaws as well. For example, most of them included only a small number of teledermatologists. Over half of the studies we identified used three or fewer teledermatologists. In addition, most of the studies employed teledermatology only in a laboratory type of setting. The few studies of real-world use of teledermatology found that most patients required subsequent face-to-face clinical encounters. The available evidence does not suggest that the cost and time commitment of teledermatology systems can be justified on the basis of reducing the need for conventional in-person evaluations.

Of course, rates of concordance alone (i.e. without the clinical context of how the patient fared) are also limited from an evidence standpoint. What we ultimately need to know is the patient outcome. In other words, did the teledermatology encounter at least provide similar care for the patient? A corollary is whether teledermatology resulted in harm from any missed diagnoses or other aspects of the telemedicine situation. These questions can only be answered in studies of clinical outcomes, none of which have yet been published.

Despite its current widespread use, additional evidence is required to conclude that store-and-forward teledermatology can be routinely substituted for face-to-face encounters in the evaluation of new referrals to dermatologists. Dermatology practice also involves follow-up visits of patients who have previously received a comprehensive dermatology evaluation. Store-and-forward teledermatology may be better suited to such follow-up visits, but there have been no published reports of experience with this type of visit. Store-and-forward techniques may also be a useful adjunct in dermatology consultations for settings in which patients are located at a great distance from the consultant (such as isolated rural settings). The published studies suggest that a proportion of such patients may successfully avoid face-to-face visits to complete the dermatology evaluation.

Tele-ophthalmology has been widely studied. This field has produced commercial systems for retinal photographs that are becoming widely used to augment face-to-face

evaluations of patients at risk for diabetic retinopathy.[60] The quality of studies in this domain is slightly higher than in dermatology, although the results are equivocal. Essentially, tele-ophthalmology results in high rates of diagnostic concordance and accuracy for some eye conditions. It appears to be most efficacious for the assessment of diabetic retinopathy. However, there are a number of diagnoses for which it fares less well, and it is often unusable altogether when certain patient characteristics are present, such as cataracts and other lens abnormalities.

Telemedicine has also been widely studied for wound care. The key observation from studies assessing telemedicine for this purpose is that all of them had small sample sizes, used only one assessor and did not compare in-person examiners when assessing concordance. Serious questions remain about their statistical power and reproducibility.

The situation of gynaecology, in particular telecolposcopy, is also instructive. Studies show that the accuracy of diagnosis by telemedicine is similar to that of face-to-face assessment. However, the accuracy of both of these approaches is poor, in the range of 50–60%.

An often-quoted benefit of telemedicine is the provision of care to rural areas, where specialists are less common and patients must travel great distances to see them. Studies of rural populations have tended to be of poorer methodological quality than studies of urban and suburban populations. The limited evidence available supports the use of office/hospital-based telemedicine for providing continuous care for stable patients by specialists. The technology required for such systems is relatively uncomplicated and can be based on widely available videoconferencing equipment.

The overall state of the evidence suggests that telemedicine deployment should continue cautiously. Naturally, there may be situations when the use of telemedicine is warranted even if the evidence is lacking, when care would be otherwise impossible to deliver. This could include remote rural areas or other locations where medical care is not available locally, and the patient is for whatever reason unable to travel to a location where it can be obtained. However, even in these instances, it is important to understand the efficacy of telemedicine so that any clinical shortcomings can be anticipated.

The present evidence base provides guidance on the clinical areas in which future research is most likely to be useful. It is now clear that continued small or methodologically weak studies are unlikely to add to the evidence base for telemedicine. In teledermatology – just as in surgery – larger and more comprehensive analyses that assess key patient outcomes are needed. Likewise, there is a need for similar studies of clinical outcomes using office/hospital-based telemedicine in fields such as psychiatry and neurology. Longitudinal observational studies and demonstration projects will also be useful. Studies of home-based telemedicine should address the independent contributions of technology and human resources in the complex delivery models for patients with chronic diseases. Further, well-designed research is required to understand how best to deploy telemedicine in health care.

Acknowledgements: This work was funded under Contract No. 290-02-0024 from the Agency for Healthcare Research and Quality.

References

1 Hersh WR, Wallace JA, Patterson PK, *et al*. *Telemedicine for the Medicare Program. Evidence Report/Technology Assessment No. 24*. See http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=hstat1.chapter.3300 (last checked 2 May 2006)
2 Hersh W, Helfand M, Wallace J, *et al*. A systematic review of the efficacy of telemedicine for making diagnostic and management decisions. *J Telemed Telecare* 2002;**8**:197–209
3 Hersh WR, Helfand M, Wallace J, *et al*. Clinical outcomes resulting from telemedicine interventions: a systematic review. *BMC Med Inf Decis Mak* 2001;**1**:5
4 Millman ML. *Access to Health Care in America*. Washington, DC: National Academy Press, 1993
5 Egglin TK, Feinstein AR. Context bias. A problem in diagnostic radiology. *JAMA* 1996;**276**:1752–5
6 Lijmer JG, Mol BW, Heisterkamp S, *et al*. Empirical evidence of design-related bias in studies of diagnostic tests. *JAMA* 1999;**282**:1061–6. Erratum in JAMA 2000; **283:** 1963
7 Chestnut R, Carney N, Maynard H, *et al*. *Rehabilitation for Traumatic Brain Injury: Evidence Report no. 2*. See http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=hstat1.chapter.128 (last checked 2 May 2006). NB: this evidence report is outdated and is no longer viewed as guidance for current medical practice
8 Berry LL, Seiders K, Wilder SS. Innovations in access to care: a patient-centered approach. *Ann Intern Med* 2003;**139**:568–74
9 Murray M, Berwick DM. Advanced access: reducing waiting and delays in primary care. *JAMA* 2003;**289**:1035–40
10 Barnard CM, Goldyne ME. Evaluation of an asynchronous teleconsultation system for diagnosis of skin cancer and other skin diseases. *Telemed J E Health* 2000;**6**:379–84
11 Taylor P, Goldsmith P, Murray K, Harris D, Barkley A. Evaluating a telemedicine system to assist in the management of dermatology referrals. *Br J Dermatol* 2001;**144**:328–33
12 Whited JD, Hall RP, Foy ME, *et al*. Teledermatology's impact on time to intervention among referrals to a dermatology consult service. *Telemed J E-Health* 2002;**8**:313–21
13 Lesher Jr JL, Davis LS, Gourdin FW, English D, Thompson WO. Telemedicine evaluation of cutaneous diseases: a blinded comparative study. *J Am Acad Dermatol* 1998;**38**:27–31
14 Shapiro M, James WD, Kessler R, *et al*. Comparison of skin biopsy triage decisions in 49 patients with pigmented lesions and skin neoplasms: store-and-forward teledermatology vs face-to-face dermatology. *Arch Dermatol* 2004;**140**:525–8
15 Jolliffe VM, Harris DW, Morris R, Wallacet P, Whittaker SJ. Can we use video images to triage pigmented lesions? *Br J Dermatol* 2001;**145**:904–10
16 Pak HS, Harden D, Cruess D, *et al*. Teledermatology: an intraobserver diagnostic correlation study, part I. *Cutis* 2003;**71**:399–403
17 Piccolo D, Soyer HP, Burgdorf W, *et al*. Concordance between telepathologic diagnosis and conventional histopathologic diagnosis: a multiobserver store-and-forward study on 20 skin specimens. *Arch Dermatol* 2002;**138**:53–8
18 Coras B, Glaessl A, Kinateder J, *et al*. Teledermatoscopy in daily routine – results of the first 100 cases. *Curr Probl Dermatol* 2003;**32**:207–12

19 Gomez-Ulla F, Fernandez MI, Gonzalez F, *et al.* Digital retinal images and teleophthalmology for detecting and grading diabetic retinopathy. *Diabetes Care* 2002;**25**:1384–9

20 Baker CF, Rudnisky CJ, Tennant MT, *et al.* JPEG compression of stereoscopic digital images for the diagnosis of diabetic retinopathy via teleophthalmology. *Can J Ophthalmol* 2004;**39**: 746–54

21 Ells AL, Holmes JM, Astle WF, *et al.* Telemedicine approach to screening for severe retinopathy of prematurity: a pilot study. *Ophthalmology* 2003;**110**:2113–17

22 Ferris DG, Litaker MS, Macfee MS, *et al.* Remote diagnosis of cervical neoplasia: 2 types of telecolposcopy compared with cervicography. *J Fam Pract* 2003;**52**:298–304

23 Ferris DG, Macfee MS, Miller JA, Litaker MS, Crawley D, Watson D. The efficacy of telecolposcopy compared with traditional colposcopy. *Obstet Gynecol* 2002;**99**:248–54

24 Lee S, Broderick TJ, Haynes J, Bagwell C, Doarn CR, Merrell RC. The role of low-bandwidth telemedicine in surgical prescreening. *J Pediatr Surg* 2003;**38**:1281–3

25 Tennant MT, Rudnisky CJ, Hinz BJ, MacDonald IM, Greve MD. Tele-ophthalmology via stereoscopic digital imaging: a pilot project. *Diabetes Technol Ther* 2000;**2**:583–7

26 Jaatinen PT, Aarnio P, Remes J, Hannukainen J, Koymari-Seilonen T. Teleconsultation as a replacement for referral to an outpatient clinic. *J Telemed Telecare* 2002;**8**:102–6

27 Mallett RB. Teledermatology in practice. *Clin Exp Dermatol* 2003;**28**:356–9

28 Benatar D, Bondmass M, Ghitelman J, Avitall B. Outcomes of chronic heart failure. *Arch Intern Med* 2003;**163**:347–52

29 Phillips VL, Vesmarovich S, Hauber R, Wiggers E, Egner A. Telehealth: reaching out to newly injured spinal cord patients. *Public Health Rep* 2001;**116** (suppl. 1):94–102

30 Noel HC, Vogel DC, Erdos JJ, Cornwall D, Levin F. Home telehealth reduces healthcare costs. *Telemed J E-Health* 2004;**10**: 170–83

31 Kobb R, Hoffman N, Lodge R, Kline S. Enhancing elder chronic care through technology and care coordination: report from a pilot. *Telemed J E-Health* 2003;**9**:189–95

32 Chan DS, Callahan CW, Sheets SJ, Moreno CN, Malone FJ. An Internet-based store-and-forward video home telehealth system for improving asthma outcomes in children. *Am J Health Syst Pharm* 2003;**60**:1976–81

33 Rogers MA, Small D, Buchan DA, *et al.* Home monitoring service improves mean arterial pressure in patients with essential hypertension. A randomized, controlled trial. *Ann Intern Med* 2001;**134**:1024–32

34 Artinian NT, Harden JK, Kronenberg MW, *et al.* Pilot study of a Web-based compliance monitoring device for patients with congestive heart failure. *Heart Lung* 2003;**32**:226–33

35 Maiolo C, Mohamed EI, Fiorani CM, De Lorenzo A. Home telemonitoring for patients with severe respiratory illness: the Italian experience. *J Telemed Telecare* 2003;**9**:67–71

36 Bellazzi R, Arcelloni M, Bensa G, *et al.* Design, methods, and evaluation directions of a multi-access service for the management of diabetes mellitus patients. *Diabetes Technol Ther* 2003;**5**: 621–9

37 Chase HP, Pearson JA, Wightman C, Roberts MD, Oderberg AD, Garg SK. Modem transmission of glucose values reduces the costs and need for clinic visits. *Diabetes Care* 2003;**26**:1475–9

38 Harvey-Berino J, Pintauro SJ, Gold EC. The feasibility of using Internet support for the maintenance of weight loss. *Behav Modif* 2002;**26**:103–16

39 Mullan B, Snyder M, Lindgren B, Finkelstein SM, Hertz MI. Home monitoring for lung transplant candidates. *Prog Transplant* 2003;**13**:176–82

40 Bowman RJ, Kennedy C, Kirwan JF, Sze P, Murdoch IE. Reliability of telemedicine for diagnosing and managing eye problems in accident and emergency departments. *Eye* 2003;**17**:743–6

41 Crowston JG, Kirwan JF, Wells A, Kennedy C, Murdoch IE. Evaluating clinical signs in trabeculectomized eyes. *Eye* 2004;**18**:299–303

42 Craig J, Chua R, Wootton R, Patterson V. A pilot study of telemedicine for new neurological outpatient referrals. *J Telemed Telecare* 2000;**6**:225–8

43 Craig J, Patterson V, Russell C, Wootton R. Interactive videoconsultation is a feasible method for neurological in-patient assessment. *Eur J Neurol* 2000;**7**:699–702

44 Handschu R, Littmann R, Reulbach U, *et al.* Telemedicine in emergency evaluation of acute stroke: interrater agreement in remote video examination with a novel multimedia system. *Stroke* 2003;**34**:2842–6

45 Wang S, Lee SB, Pardue C, *et al.* Remote evaluation of acute ischemic stroke: reliability of National Institutes of Health Stroke Scale via telestroke. *Stroke* 2003;**34**:188–91

46 Menon AS, Kondapavalru P, Krishna P, *et al.* Evaluation of a portable low cost videophone system in the assessment of depressive symptoms and cognitive function in elderly medically ill veterans. *J Nerv Ment Dis* 2001;**189**:399–401

47 Shores MM, Ryan-Dykes P, Williams RM, *et al.* Identifying undiagnosed dementia in residential care veterans: comparing telemedicine to in-person clinical examination. *Int J Geriatr Psychiatry* 2004;**19**:101–8

48 Nordal EJ, Moseng D, Kvammen B, Lochen ML. A comparative study of teleconsultations versus face-to-face consultations. *J Telemed Telecare* 2001;**7**:257–65

49 Leggett P, Graham L, Steele K, *et al.* Telerheumatology – diagnostic accuracy and acceptability to patient, specialist, and general practitioner. *Br J Gen Pract* 2001;**51**:746–8

50 Endean ED, Mallon LI, Minion DJ, Kwolek CJ, Schwarcz TH. Telemedicine in vascular surgery: does it work? *Am Surg* 2001;**67**:334–40; discussion 340–1

51 Mashima PA, Birkmire-Peters DP, Syms MJ, *et al.* Telehealth: voice therapy using telecommunications technology. *Am J Speech Lang Pathol* 2003;**12**:432–9

52 Ruskin PE, Silver-Aylaian M, Kling MA, *et al.* Treatment outcomes in depression: comparison of remote treatment through telepsychiatry to in-person treatment. *Am J Psychiatry* 2004;**161**:1471–6

53 Nelson EL, Barnard M, Cain S. Treating childhood depression over videoconferencing. *Telemed J E-Health* 2003;**9**:49–55

54 Woods KF, Johnson JA, Kutlar A, Daitch L, Stachura ME. Sickle cell disease telemedicine network for rural outreach. *J Telemed Telecare* 2000;**6**:285–90

55 Kennedy C, Yellowlees P. The effectiveness of telepsychiatry measured using the Health of the Nation Outcome Scale and the Mental Health Inventory. *J Telemed Telecare* 2003;**9**:12–16

56 Chua R, Craig J, Esmonde T, Wootton R, Patterson V. Telemedicine for new neurological outpatients: putting a randomized controlled trial in the context of everyday practice. *J Telemed Telecare* 2002;**8**:270–3

57 Wallace P, Haines A, Harrison R, *et al.* Joint teleconsultations (virtual outreach) versus standard outpatient appointments for patients referred by their general practitioner for a specialist opinion: a randomised trial. *Lancet* 2002;**359**:1961–8

58 Vuolio S, Winblad I, Ohinmaa A, Haukipuro K. Videoconferencing for orthopaedic outpatients: one-year follow-up. *J Telemed Telecare* 2003;**9**:8–11

59 LaMonte MP, Bahouth MN, Hu P, *et al.* Telemedicine for acute stroke: triumphs and pitfalls. *Stroke* 2003;**34**:725–8

60 Cavallerano AA, Cavallerano JD, Katalinic P, *et al.* Use of Joslin Vision Network digital-video nonmydriatic retinal imaging to assess diabetic retinopathy in a clinical program. *Retina* 2003;**23**:215–23

61 Dahl LB, Hasvold P, Arild E, Hasvold T. Heart murmurs recorded by a sensor based electronic stethoscope and e-mailed for remote assessment. *Arch Dis Child* 2002;**87**:297–301; discussion 297–301

62 Du Moulin MF, Bullens-Goessens YI, Henquet CJ, *et al*. The reliability of diagnosis using store-and-forward teledermatology. *J Telemed Telecare* 2003;**9**:249–52
63 Eminovic N, Witkamp L, Ravelli AC, *et al*. Potential effect of patient-assisted teledermatology on outpatient referral rates. *J Telemed Telecare* 2003;**9**:321–7
64 Jolliffe VM, Harris DW, Whittaker SJ. Can we safely diagnose pigmented lesions from stored video images? A diagnostic comparison between clinical examination and stored video images of pigmented lesions removed for histology. *Clin Exp Dermatol* 2001;**26**:84–7
65 Lim AC, Egerton IB, See A, Shumack SP. Accuracy and reliability of store-and-forward teledermatology: preliminary results from the St George Teledermatology Project. *Australas J Dermatol* 2001;**42**:247–51
66 Oztas MO, Calikoglu E, Baz K, *et al*. Reliability of Web-based teledermatology consultations. *J Telemed Telecare* 2004;**10**:25–8
67 Pak HS, Harden D, Cruess D, *et al*. Teledermatology: an intraobserver diagnostic correlation study, Part II. *Cutis* 2003;**71**:476–80
68 Rashid E, Ishtiaq O, Gilani S, Zafar A. Comparison of store and forward method of teledermatology with face-to-face consultation. *J Ayub Med Coll Abbottabad* 2003;**15**:34–6
69 Kim CY, Etemad B, Glenn TF, *et al*. Remote clinical assessment of gastrointestinal endoscopy (tele-endoscopy): an initial experience. *Proc AMIA Symp* 2000;423–7
70 Wildi SM, Kim CY, Glenn TF, *et al*. Tele-endoscopy: a way to provide diagnostic quality for remote populations. *Gastrointest Endosc* 2004;**59**:38–43
71 Etherington IJ. Telecolposcopy – a feasibility study in primary care. *J Telemed Telecare* 2002;**8** (suppl. 2):22–4
72 Saari JM, Summanen P, Kivela T, Saari KM. Sensitivity and specificity of digital retinal images in grading diabetic retinopathy. *Acta Ophthalmol Scand* 2004;**82**:126–30
73 Shiba T, Yamamoto T, Seki U, *et al*. Screening and follow-up of diabetic retinopathy using a new mosaic 9-field fundus photography system. *Diabetes Res Clin Pract* 2002;**55**:49–59
74 Barry CJ, Eikelboom RH, McAllister IL, Tay-Kearney ML. Telemedicine screening of diabetic retinopathy using a hand-held fundus camera. *Telemed J* 2000;**6**:219–23
75 Braun RP, Vecchietti JL, Thomas L, *et al*. Telemedical wound care using a new generation of mobile telephones: a feasibility study. *Arch Dermatol* 2005;**141**:254–8
76 Gardner SE, Frantz RA, Specht JK, *et al*. How accurate are chronic wound assessments using interactive video technology? *J Gerontol Nurs* 2001;**27**:15–20; quiz 52–3
77 Halstead LS, Dang T, Elrod M, Convit RJ, Rosen MJ, Woods S. Teleassessment compared with live assessment of pressure ulcers in a wound clinic: a pilot study. *Adv Skin Wound Care* 2003;**16**:91–6
78 Houghton PE, Kincaid CB, Campbell KE, Woodbury MG, Keast DH. Photographic assessment of the appearance of chronic pressure and leg ulcers. *Ostomy Wound Manage* 2000;**46**:20–6
79 Jones OC, Wilson DI, Andrews S. The reliability of digital images when used to assess burn wounds. *J Telemed Telecare* 2003;**9** (suppl. 1):22–4
80 Jones SM, Milroy C, Pickford MA. Telemedicine in acute plastic surgical trauma and burns. *Ann R Coll Surg Engl* 2004;**86**:239–42
81 Kim HM, Lowery JC, Hamill JB, Wilkins EG. Accuracy of a web-based system for monitoring chronic wounds. *Telemed J E-Health* 2003;**9**:129–40
82 Jenkins RL, McSweeney M. Assessing elderly patients with congestive heart failure via in-home interactive telecommunication. *J Gerontol Nurs* 2001;**27**:21–7
83 Morlion B, Knoop C, Paiva M, Estenne M. Internet-based home monitoring of pulmonary function after lung transplantation. *Am J Respir Crit Care Med* 2002;**165**:694–7
84 de Lusignan S, Wells S, Johnson P, Meredith K, Leatham E. Compliance and effectiveness of 1 year's home telemonitoring. The report of a pilot study of patients with chronic heart failure. *Eur J Heart Fail* 2001;**3**:723–30
85 Jerant AF, Azari R, Martinez C, Nesbitt TS. A randomized trial of telenursing to reduce hospitalization for heart failure: patient-centered outcomes and nursing indicators. *Home Health Care Serv Q* 2003;**22**:1–20
86 LaFramboise LM, Todero CM, Zimmerman L, Agrawal S. Comparison of Health Buddy with traditional approaches to heart failure management. *Fam Commun Health* 2003;**26**:275–88
87 Roth A, Kajiloti I, Elkayam I, Sander J, Kehati M, Golovner M. Telecardiology for patients with chronic heart failure: the 'SHL' experience in Israel. *Int J Cardiol* 2004;**97**:49–55
88 Chumbler NR, Mann WC, Wu S, Schmid A, Kobb R. The association of home-telehealth use and care coordination with improvement of functional and cognitive functioning in frail elderly men. *Telemed J E-Health* 2004;**10**:129–37
89 Ades PA, Pashkow FJ, Fletcher G, Pina IL, Zohman LR, Nestor JR. A controlled trial of cardiac rehabilitation in the home setting using electrocardiographic and voice transtelephonic monitoring. *Am Heart J* 2000;**139**:543–8
90 Barnason S, Zimmerman L, Nieveen J, Schmaderer M, Carranza B, Reilly S. Impact of a home communication intervention for coronary artery bypass graft patients with ischemic heart failure on self-efficacy, coronary disease risk factor modification, and functioning. *Heart Lung* 2003;**32**:147–58
91 Biermann E, Dietrich W, Rihl J, Standl E. Are there time and cost savings by using telemanagement for patients on intensified insulin therapy? A randomised, controlled trial. *Comput Methods Programs Biomed* 2002;**69**:137–46
92 Izquierdo RE, Knudson PE, Meyer S, Kearns J, Ploutz-Snyder R, Weinstock RS. A comparison of diabetes education administered through telemedicine versus in person. *Diabetes Care* 2003;**26**:1002–7
93 Welch G, Sokolove M, Mullin C, Master P, Horton E. Use of a modem-equipped blood glucose meter augmented with bi-weekly educator telephone support lowers HbA1c in Type 1 diabetes. *Diabetes* 2003;**52** (suppl. 1):A100–A101
94 Montori VM, Helgemoe PK, Guyatt GH, *et al*. Telecare for patients with type 1 diabetes and inadequate glycemic control: a randomized controlled trial and meta-analysis. *Diabetes Care* 2004;**27**:1088–94
95 Artinian NT, Washington OG, Templin TN. Effects of home telemonitoring and community-based monitoring on blood pressure control in urban African Americans: a pilot study. *Heart Lung* 2001;**30**:191–9
96 Bondmass M, Bolger N, Castro G, Avitall B. The effect of home monitoring and telemanagement on blood pressure control among African Americans. *Telemed J* 2000;**6**:15–23
97 Mullan B, Snyder M, Lindgren B, Finkelstein SM, Hertz MI. Home monitoring for lung transplant candidates. *Prog Transplant* 2003;**13**:176–82
98 Egner A, Phillips VL, Vora R, Wiggers E. Depression, fatigue, and health-related quality of life among people with advanced multiple sclerosis: results from an exploratory telerehabilitation study. *NeuroRehabilitation* 2003;**18**:125–33
99 Phillips VL, Vesmarovich S, Hauber R, Wiggers E, Egner A. Telehealth: reaching out to newly injured spinal cord patients. *Public Health Rep* 2001;**116** (suppl. 1):94–102
100 Harvey-Berino J, Pintauro SJ, Gold EC. The feasibility of using Internet support for the maintenance of weight loss. *Behav Modif* 2002;**26**:103–16
101 Chan DS, Callahan CW, Sheets SJ, Moreno CN, Malone FJ. An Internet-based store-and-forward video home telehealth system for improving asthma outcomes in children. *Am J Health Syst Pharm* 2003;**60**:1976–81
102 D'Souza R. Improving treatment adherence and longitudinal outcomes in patients with a serious mental illness by using telemedicine. *J Telemed Telecare* 2002;**8** (suppl. 2):113–15

103 Maiolo C, Mohamed EI, Fiorani CM, *et al*. Home telemonitoring for patients with severe respiratory illness: the Italian experience. *J Telemed Telecare* 2003;**9**:67–71

104 Scalvini S, Zanelli E, Conti C, *et al*. Assessment of prehospital chest pain using telecardiology. *J Telemed Telecare* 2002;**8**:231–6

105 Terkelsen CJ, Norgaard BL, Lassen JF, *et al*. Telemedicine used for remote prehospital diagnosing in patients suspected of acute myocardial infarction. *J Intern Med* 2002;**252**:412–20

106 Nordal EJ, Moseng D, Kvammen B, Lochen ML. A comparative study of teleconsultations versus face-to-face consultations. *J Telemed Telecare* 2001;**7**:257–65

107 Craig J, Patterson V, Russell C, Wootton R. Interactive videoconsultation is a feasible method for neurological in-patient assessment. *Eur J Neurol* 2000;**7**:699–702

108 Handschu R, Littmann R, Reulbach U, *et al*. Telemedicine in emergency evaluation of acute stroke: interrater agreement in remote video examination with a novel multimedia system. *Stroke* 2003;**34**:2842–6

109 Wang S, Lee SB, Pardue C, *et al*. Remote evaluation of acute ischemic stroke: reliability of National Institutes of Health Stroke Scale via telestroke. *Stroke* 2003;**34**:e188–e91

110 Bowman RJ, Kennedy C, Kirwan JF, Sze P, Murdoch IE. Reliability of telemedicine for diagnosing and managing eye problems in accident and emergency departments. *Eye* 2003;**17**:743–6

111 Cheung JC, Dick PT, Kraft SP, Yamada J, Macarthur C. Strabismus examination by telemedicine. *Ophthalmology* 1999;**107**: 1999–2005

112 Crowston JG, Kirwan JF, Wells A, Kennedy C, Murdoch IE. Evaluating clinical signs in trabeculectomized eyes. *Eye* 2004;**18**:299–303

113 Dawson E, Kennedy C, Bentley C, Lee J, Murdoch I. The role of telemedicine in the assessment of strabismus. *J Telemed Telecare* 2002;**8**:52–5

114 Rayner S, Beaconsfield M, Kennedy C, Collin R, Taylor P, Murdoch I. Subspecialty adnexal ophthalmological examination using telemedicine. *J Telemed Telecare* 2001;**7** (suppl. 1):29–31

115 Smith LF, Bainbridge J, Burns J, Stevens J, Taylor P, Murdoch I. Evaluation of telemedicine for slit lamp examination of the eye following cataract surgery. *Br J Ophthalmol* 2003;**87**:502–3

116 Givens GD, Elangovan S. Internet application to tele-audiology – 'nothing' but net'. *Am J Audiol* 2003;**12**:59–65

117 Ullah R, Gilliland D, Adams D. Otolaryngology consultations by real-time telemedicine. *Ulster Med J* 2002;**71**:26–9

118 Menon AS, Kondapavalru P, Krishna P, *et al*. Evaluation of a portable low cost videophone system in the assessment of depressive symptoms and cognitive function in elderly medically ill veterans. *J Nerv Ment Dis* 2001;**189**:399–401

119 Shores MM, Ryan-Dykes P, Williams RM, *et al*. Identifying undiagnosed dementia in residential care veterans: comparing telemedicine to in-person clinical examination. *Int J Geriatr Psychiatry* 2004;**19**:101–8

120 Yoshino A, Shigemura J, Kobayashi Y, *et al*. Telepsychiatry: assessment of televideo psychiatric interview reliability with present- and next-generation internet infrastructures. *Acta Psychiatr Scand* 2001;**104**:223–6

121 Leggett P, Graham L, Steele K, *et al*. Telerheumatology – diagnostic accuracy and acceptability to patient, specialist, and general practitioner. *Br J Gen Pract* 2001;**51**:746–8

122 Endean ED, Mallon LI, Minion DJ, Kwolek CJ, Schwarcz TH. Telemedicine in vascular surgery: does it work? *Am Surg* 2001;**67**:334–40; discussion 340–1

123 Breslow MJ, Rosenfeld BA, Doerfler M, *et al*. Effect of a multiple-site intensive care unit telemedicine program on clinical and economic outcomes: an alternative paradigm for intensivist staffing. *Crit Care Med* 2004;**32**:31–8

124 Marcin JP, Nesbitt TS, Kallas HJ, Struve SN, Traugott CA, Dimand RJ. Use of telemedicine to provide pediatric critical care inpatient consultations to underserved rural Northern California. *J Pediatr* 2004;**144**:375–80

125 Chua R, Craig J, Wootton R, Patterson V. Randomised controlled trial of telemedicine for new neurological outpatient referrals. *J Neurol Neurosurg Psychiatry* 2001;**71**:63–6

126 Russell TG, Jull GA, Wootton R. Can the Internet be used as a medium to evaluate knee angle? *Man Ther* 2003;**8**:242–6

127 Vuolio S, Winblad I, Ohinmaa A, Haukipuro K. Videoconferencing for orthopaedic outpatients: one-year follow-up. *J Telemed Telecare* 2003;**9**:8–11

128 Mashima PA, Birkmire-Peters DP, Syms MJ, Holtel MR, Burgess LP, Peters LJ. Telehealth: voice therapy using telecommunications technology. *Am J Speech Lang Pathol* 2003;**12**:432–9

129 Bouchard S, Paquin B, Payeur R, *et al*. Delivering cognitive-behavior therapy for panic disorder with agoraphobia in videoconference. *Telemed J E-Health* 2004;**10**:13–25

130 Kennedy C, Yellowlees P. The effectiveness of telepsychiatry measured using the Health of the Nation Outcome Scale and the Mental Health Inventory. *J Telemed Telecare* 2003;**9**:12–16

131 Nelson EL, Barnard M, Cain S. Treating childhood depression over videoconferencing. *Telemed J E-Health* 2003;**9**:49–55

132 Ruskin PE, Silver-Aylaian M, Kling MA, *et al*. Treatment outcomes in depression: comparison of remote treatment through telepsychiatry to in-person treatment. *Am J Psychiatry* 2004;**161**:1471–6

133 Wilbright WA, Birke JA, Patout CA, Varnado M, Horswell R. The use of telemedicine in the management of diabetes-related foot ulceration: a pilot study. *Adv Skin Wound Care* 2004;**17**:232–8

134 LaMonte MP, Bahouth MN, Hu P, *et al*. Telemedicine for acute stroke: triumphs and pitfalls. *Stroke* 2003;**34**:725–8

135 Woods KF, Johnson JA, Kutlar A, Daitch L, Stachura ME. Sickle cell disease telemedicine network for rural outreach. *J Telemed Telecare* 2000;**6**:285–90

136 Haukipuro K, Ohinmaa A, Winblad I, Linden T, Vuolio S. The feasibility of telemedicine for orthopaedic outpatient clinics – a randomized controlled trial. *J Telemed Telecare* 2000;**6**:193–8

137 Wallace P, Haines A, Harrison R, *et al*. Joint teleconsultations (virtual outreach) versus standard outpatient appointments for patients referred by their general practitioner for a specialist opinion: a randomised trial. *Lancet* 2002;**359**:1961–8

138 Chua R, Craig J, Esmonde T, Wootton R, Patterson V. Telemedicine for new neurological outpatients: putting a randomized controlled trial in the context of everyday practice. *J Telemed Telecare* 2002;**8**:270–3

139 Taylor P, Kennedy C, Murdoch I, Johnston K, Cook C, Godoumov R. Assessment of benefit in tele-ophthalmology using a consensus panel. *J Telemed Telecare* 2003;**9**:140–5

Appendix 1: Search strings

Database: Ovid MEDLINE(R) Version: re l9.2.0

1. exp TELEMEDICINE
2. telemedicine.mp.
3. telehealth.mp.
4. remote consultation$.mp.
5. 1 or 2 or 3 or 4
6. exp Home Care Services
7. Home Nursing
8. 6 or 7
9. exp Therapy, Computer-Assisted
10. exp COMPUTERS
11. exp Computer Communication Networks
12. exp Medical Informatics

13. exp TELECOMMUNICATIONS
14. exp Monitoring, Physiologic
15. monitor$.mp.
16. blood glucose self-monitoring
17. Self-Examination
18. self exam$.mp.
19. self monitor$.mp.
20. self test$.mp.
21. 14 or 15 or 16 or 17 or 18 or 19 or 20
22. tele$.mp.
23. (remote or offsite or distance).mp.
24. Rural Population
25. Rural Health Services
26. HOSPITALS, RURAL
27. rural.mp.
28. 22 or 23 or 24 or 25 or 26 or 27
29. 21 and 28
30. 9 or 10 or 11 or 12 or 13 or 29
31. 8 and 30
32. 31 not 5
33. limit 32 to english language
34. 32 not 33
35. limit 34 to abstracts
36. 33 or 35
37. 5 or 36
38. limit 37 to yr = 2000–2004
39. exp Computer Communication Networks
40. Patient Participation
41. exp Consumer Satisfaction
42. 'Delivery of Health Care'
43. exp Home Care Services
44. exp Home Nursing
45. house calls/or house call$.mp. or housecall$.mp.
46. 40 or 41 or 42 or 43 or 44 or 45
47. 39 and 46
48. limit 47 to english language
49. limit 48 to yr = 2000–2004
50. 38 or 49