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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-Based Practice Centers (EPCs), sponsors the development of evidence reports and technology assessments to assist public- and private-sector organizations in their efforts to improve the quality of health care in the United States. This report was requested and funded by the Centers for Medicare & Medicaid Services. The reports and assessments provide organizations with comprehensive, science-based information on common, costly medical conditions and new health care technologies. The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments.

To bring the broadest range of experts into the development of evidence reports and health technology assessments, AHRQ encourages the EPCs to form partnerships and enter into collaborations with other medical and research organizations. The EPCs work with these partner organizations to ensure that the evidence reports and technology assessments they produce will become building blocks for health care quality improvement projects throughout the Nation. The reports undergo peer review prior to their release.

AHRQ expects that the EPC evidence reports and technology assessments will inform individual health plans, providers, and purchasers as well as the health care system as a whole by providing important information to help improve health care quality.

We welcome comments on this evidence report. They may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 540 Gaither Road, Rockville, MD 20850, or by e-mail to **epc@ahrq.gov.**

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Structured Abstract

Context. Telemedicine services are increasingly utilized by patients, clinicians, and institutions. Although private and Federal insurers are covering some telemedicine services, the rationale for these coverage decisions is not always evidence-based.

Objectives. The goal of this report was to assess the peer-reviewed literature for telemedicine services that substitute for face-to-face medical diagnosis and treatment that may apply to the Medicare population. We focused on three distinct areas: store-and-forward, home-based, and office/hospital-based services. We also sought to identify what progress had been made in expanding the evidence base since the publication of our initial report in 2001 (AHRQ Publication No. 01-E012.)

Data Sources. Ovid MEDLINE®, reference lists of included studies, and non-indexed materials recommended by telemedicine experts.

Study Selection. Included studies had to be relevant to at least one of the three study areas, address at least one key question, and contain reported results. We excluded articles that did not study the Medicare population (e.g., children and pregnant adults) or used a service that does not require face-to-face encounters (e.g., radiology or pathology diagnosis).

Data Extraction. Our literature searches initially identified 4,083 citations. Using a dual-review process, 597 of these were judged to be potentially relevant to our study at the title/abstract level. Following a full-text review, 97 studies were identified that met our inclusion criteria and were subsequently included in the report's evidence tables.

Data Synthesis. Store-and-forward services have been studied in many specialties, the most prominent being dermatology, wound care, and ophthalmology. The evidence for their efficacy is mixed, and in most areas, there are not corresponding studies on outcomes or improved access to care.

Several limited studies showed the benefits of home-based telemedicine interventions in chronic diseases. These interventions 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.

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.

Conclusions. 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 and targeted research that provides high-quality data will provide a strong contribution to understanding how best to deploy technological resources in health care.

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Executive Summary

Overview

Telemedicine is the use of telecommunications technology for medical diagnostic, monitoring, and therapeutic purposes where distance and/or time separates the patient and health care provider. Both federal and private health insurers are now covering some telemedicine services, despite the fact that the benefits and costs of providing many of these services have not been well studied.

This report assesses the peer-reviewed literature of specific telemedicine study areas, with a focus on those that substitute for face-to-face medical diagnosis and treatment of the Medicare population. Thus, this report targets face-to-face clinical specialties (as opposed to radiology and pathology) and the Medicare population. It does not evaluate studies examining populations that usually are not covered by Medicare, such as children and pregnant women. The report identifies health care services that could be provided using telemedicine and describes existing programs in three categories of telemedicine: store-and-forward, home-based and office/hospital-based services.

Introduction

This evidence report provides an update on the state of telemedicine, following the 2001 publication of *Telemedicine for the Medicare Population*.[1] It identifies whether there has been significant progress in the number and types of telemedicine studies being conducted. More specifically, we searched for well-designed studies that evaluated telemedicine services in three technological categories described below.

Store-and-forward Telemedicine

In *store-and-forward* telemedicine, clinical data are collected, stored, and then forwarded to be interpreted later. A store-and-forward system eliminates the need for the patient and the clinician to be available at either the same time or place. The following key questions were addressed for store-and-forward telemedicine services in Medicare-eligible patient populations.

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

Home-based Telemedicine

Home-based telemedicine services enable physicians and other health care providers to monitor physiologic measurements, test results, images, and sounds, usually collected in a patient's residence or a care facility. The use of home-based telemedicine services in Medicare-eligible patient populations was examined, asking the following questions relative to conventional care using face-to-face encounters.

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

Office/Hospital-based Telemedicine

Office/hospital-based telemedicine services are real-time clinician-patient interactions that substitute for face-to-face encounters between a patient and a physician or other health care provider. The use of office/hospital-based telemedicine was evaluated relative to face-to-face encounters on the basis of the following questions.

1. *Does office/hospital-based telemedicine result in comparable diagnosis and appropriateness of recommendations for management?*
2. *Does office/hospital-based telemedicine result in comparable health outcomes?*
3. *Does the availability of office/hospital-based telemedicine improve access to care?*

Methods

The Oregon Evidence-based Practice Center (EPC) team that developed this report sought to identify peer-reviewed literature in the three study areas. We searched the peer-reviewed literature using the Ovid MEDLINE® electronic bibliographic database. We also searched through telemedicine reports and compilations, including their reference lists.

The inclusion criteria for the evidence report update were that the study was relevant to at least one of the three study areas, addressed at least one key question in the analytic framework for that study area, and contained reported results. Exclusion criteria for the evidence report update were that the study did not address a key question, lacked reported results, had a study population that was not relevant to the Medicare population (i.e., children and pregnant adults) or substituted for a service that did not historically require face-to-face encounters (e.g., diagnostic services in radiology or pathology).

We categorized the included articles by the key question(s) they addressed. The included studies for each study area and key question were critically appraised to determine the strengths and limitations of the most important studies following a detailed rationale for the appraisal of study characteristics related to quality.

For each study area, we constructed an evidence table summarizing the strength of the evidence for each key question. We then constructed summary tables for clinical specialties or domains. For studies of diagnosis and management decisions, we explicitly noted whether studies assessed concordance (without a diagnostic gold standard) or accuracy (with a gold standard) of the telemedicine system when compared to conventional care.

Results

General Observations

Following review of the abstracts of all studies retrieved in the literature search, a total of 597 citations were determined potentially to have evidence for the efficacy of one of the three study areas. The full text of these 597 articles was reviewed. After exclusion criteria were applied, there were 97 articles included in evidence tables. Of these, 35 articles assessed store-and-forward telemedicine services, 27 articles evaluated home-based services, and 38 articles assessed office/hospital-based services. Some studies assessed more than one telemedicine study area.

Specific Results

Individual studies were assessed for evidence based on criteria applicable to the study question. Studies were too heterogeneous to undertake any quantitative aggregate analyses such as meta-analysis.

Store-and-forward telemedicine. Similar to our original evidence report, the studies we found of store-and-forward telemedicine only assessed diagnosis or management decisions and not outcomes. As we also found in the original report, some aspects of the telemedicine systems used in home and office-hospital settings made use of store-and-forward techniques, but in the context of larger and/or interactive interventions.

1. *Does store-and-forward telemedicine result in comparable diagnostic decisions and recommendations for clinical management?*

Similar to the original report, the largest number of studies came from the specialty of dermatology. The most commonly assessed aspect of teledermatology was interobserver concordance. The range of concordance varied widely, from 41 percent to 87 percent for complete agreement to 51 percent to 96 percent for disease-category agreement. All of these studies were limited by the lack of measurement of concordance among more than one face-to-face examiner. Concordance studies assessing management decisions typically looked at decision to biopsy. While one study found complete agreement, others found lesser concordance. The studies of diagnostic accuracy typically compared the telemedicine diagnosis to some sort of gold standard, often a biopsy of a pigmented lesion. In these studies, telemedicine generally was nearly as good as face-to-face in correctness of diagnosis. The second most frequently studied clinical area was wound care. These studies demonstrated that some characteristics of skin wounds and ulcerations could be assessed effectively using store-and-forward telemedicine. However, most of these studies had small numbers of patients and very small numbers of clinicians, raising statistical power issues. Five studies provide data on store-and-forward applications in ophthalmology. Four of these studies show that a high accuracy of diagnosing diabetic retinopathy could be obtained. Other specialties studied included gynecology and gastroenterology.

2. *Does store-and-forward telemedicine result in comparable health outcomes?*

Similar to the previous report, there were no studies that assessed health outcomes using store-and-forward telemedicine interventions. This is problematic for assessing the overall benefit of store-and-forward telemedicine, since the outcomes from its use for diagnosis and management decisions are unclear.

3. *Does the availability of store-and-forward telemedicine services improve access to care?*

When store-and-forward telemedicine systems have been evaluated as a method for performing specialty consultations of patients followed by general practitioners or primary care clinicians, the systems have had only a small impact on reducing the need for subsequent face-to-face clinical evaluations by specialists. While these systems can aid in the triage of patients referred for consultation, they have not been shown conclusively either to improve access to care or to have a negative influence on access to care. Five studies reported evidence on the effect of store-and-forward techniques upon access to care. The methodologic quality of these studies generally was low.

Home-based telemedicine. Home-based telemedicine is most commonly used for management of chronic diseases or specific conditions, such as heart disease, diabetes mellitus, and rehabilitation. Some studies show telemedicine applied in this setting can be efficacious, although many are limited by small sample sizes, inadequate length of follow-up, and inconclusive results.

1. *Does home-based telemedicine result in comparable diagnostic decisions and recommendations for management?*

Two studies assessed diagnostic capabilities in the home in the areas of congestive heart failure assessment and pulmonary function monitoring. These studies found various levels of agreement and disagreement depending on the specific observation.

2. *Does home-based telemedicine result in comparable health outcomes?*

A variety of published studies have assessed chronic diseases afflicting patients in the Medicare population, such as congestive heart failure, diabetes mellitus, coronary artery disease, and hypertension. Unfortunately, the studies are very heterogeneous, and their limitations prevent broad conclusions. Interventions showing multi-faceted interventions demonstrate more benefit than single interventions, such as monitoring of blood sugar or blood pressure. However, in most studies, it is not possible to assess whether improved outcomes are due to the increased level of care provided by dedicated clinical staff versus the technology intervention.

3. *Does the use of home-based telemedicine improve access to care?*

No studies were identified that examined the effect of home-based telemedicine services on access to care.

Office/hospital-based telemedicine. A variety of studies were found that assessed office/hospital-based telemedicine. The largest number of studies assessed diagnosis and management decisions, and these studies examined a broad range of medical specialties. There were, however, very few studies of high methodologic quality.

1. *Does office/hospital-based telemedicine services result in comparable diagnosis and appropriateness of recommendations for management?*

For diagnosis and management decisions, the most frequently studied specialty was ophthalmology. As with store-and-forward studies, some aspects of ophthalmologic evaluation were amenable to interactive telemedicine, while others were not. Other frequently studied specialties included neurology and psychiatry, which demonstrated that some diagnostic assessments can be successfully administered via telemedicine.

2. *Does office/hospital-based telemedicine result in comparable health outcomes?*

Studies of outcomes also showed that for most of the clinical specialties assessed, outcomes with telemedicine interventions are comparable to those using conventional clinical evaluations. However, most of these studies are limited by small sample sizes and/or other problems. None of these studies attempted to measure their statistical power to avoid type-2 (beta) errors.

3. *Does the availability of office/hospital-based telemedicine improve access to care?*

Studies having relatively weak methodologies suggest that office/hospital-based telemedicine can improve access to care for patients in rural locations in medical applications in which patient evaluations can be performed using standard teleconferencing equipment.

Discussion

This update on evidence about the efficacy of telemedicine for the Medicare population covered published peer-reviewed literature for the five years between 2000 and 2004. Similar to the findings of our original report a half-decade ago, there are still serious gaps in the evidence base for telemedicine. While this situation is hardly unique to telemedicine, having a solid evidence base is essential given that there is increased advocacy for health care payers, especially Medicare, to provide coverage for its use.

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. Various psychiatric and neurological assessments can be administered effectively via interactive videoconferencing. Likewise, treatments administered in these specialties via telemedicine appear to achieve comparability with face-to-face care.

Our systematic review also identified several studies, a few of them of high methodologic quality, showing 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. With ongoing improvements in telecommunications technology, particularly broadband connections to the home, further research, including larger clinical trials, will likely be informative.

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 this report is consistent with the findings of the earlier report. There continues to be highly variable rates of interobserver and intraobserver agreement in diagnoses. This issue can only be resolved by high-quality studies that compare not only the concordance of telemedicine versus face-to-face diagnosis, but also the concordance of face-to-face versus face-to-face diagnosis in the same situation.

Of course, rates of concordance in a vacuum, i.e., without a 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 comparable care for the patient? A corollary question that must be answered is whether teledermatology resulted in harm from any missed diagnoses or other consequences of the telemedicine encounter. These questions can only be answered in studies of clinical outcomes, none of which were identified in this report. In general, advocacy for an expanded role for teledermatology will require further studies that examine rates of missed diagnoses, incorrect treatments, and when the technology is insufficient to avoid in-person encounters.

Other widely studied domains include ophthalmology and wound care. Teleophthalmology appears to result in high rates of diagnostic concordance and accuracy, but only for some eye conditions. It appears to be particularly efficacious in assessment of diabetic retinopathy. Studies of wound care show potential, but are limited by small sample sizes, use of only one assessor, and lacking comparison to other in-person examiners when assessing concordance.

There may be situations when the use of telemedicine is warranted even if the evidence is lacking. For example, there may be situations when care would be otherwise impossible to deliver except via telemedicine. 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 setting 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 now is clear that continued small or methodologically weak studies are unlikely to add to the evidence base for telemedicine. In teledermatology, 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. Well-designed randomized controlled trials will likely provide valuable information on the potential of these clinical applications. Longitudinal observational studies and demonstration projects also will be useful. Studies of home-based telemedicine should carefully address the independent contributions of technology and human resources in the complex delivery models for patients with chronic diseases.

Evidence Report

Chapter 1. Introduction

Goal of the Report

The goal of this report is to present an overview of the scientific evidence on diagnosis and management decisions, clinical outcomes, and access to services through the use of three categories of telemedicine services: store-and-forward, home-based, and office/hospital-based. The report is intended to provide an update on the evidence for the efficacy of telemedicine services in the Medicare population. Consequently, the scope of this report is limited to telemedicine programs and clinical settings that have been used for, or are likely to be applied to, Medicare beneficiaries.

This report provides an update on the state of telemedicine, following the 2001 publication of *Telemedicine for the Medicare Population* (AHRQ Publication No. 01-E012).[1] Our initial report found that while telemedicine was in widespread use, the evidence of efficacy for those uses was lacking. But even more problematic was the quality of evaluative studies. Many studies were performed using poor methodologies and small sample sizes. Indeed, our major conclusion was not that telemedicine was not efficacious, but rather that the quality of the studies evaluating it prevented one from making that determination at all. Another goal of the current report is to determine whether there has been progress in the number and quality of telemedicine studies that have been conducted since then.

We note that this report only presents a view of telemedicine from the standpoint of the peer-reviewed medical literature. This does not represent the sum of all experience with telemedicine. Indeed, telemedicine continues to be widely used. According to the *2004 TRC Report on Telemedicine Activity* (Telemedicine Research Center and Telemedicine Information Exchange),[2] 48,194 non-radiology teleconsultations took place in 2003 in 46 states. Mental health, cardiology, dermatology, orthopedics, and neurology represent some of the clinical specialties most actively utilizing telemedicine services. This report also identified a number of barriers to telemedicine services. The most significant of these barriers are the difficulty associated with integrating telemedicine services into health care delivery, lack of long-term funding, and lack of reimbursement for the provision of telemedicine services.[2]

Despite the peer-reviewed literature representing only a subset of all telemedicine experience, it is important to analyze telemedicine using an evidence-based approach, especially when the goal is to inform decisions about coverage. As such, this report undertakes a systematic if limited review of the efficacy for the telemedicine services and usages described above.

Definitions

Telemedicine is the use of telecommunications technology for medical diagnostic, monitoring, and therapeutic purposes when distance and/or time separates the participants. Some descriptions use the broader term *telehealth* to indicate care beyond that provided in medical encounters (e.g., health education, health-related Web sites, etc.). Other descriptions use narrower terms focused on medical specialties, such as *teledermatology* or *teleradiology*. A telemedicine *encounter* is the event where clinical services are provided using telemedicine. The narrower term *teleconsultation* is used when a traditional specialist medical consultation is performed using telemedicine.

Telemedicine Study Areas

This report examines telemedicine services in three areas: *store-and-forward*, *home-based,* and *office/hospital-based* services. Each of these three services are evaluated for their efficacy in three functions: *diagnosis and management decisions*, *clinical outcomes,* and *access to care*. Because the decision to use telemedicine is only predicated on it performing comparably to face-to-face care, studies are assessed from the standpoint of telemedicine to perform comparable to, but not necessarily better than, conventional care.

The terminology used in this update varies from the terminology used in the 2001 report. The term *self-monitoring/testing* has been replaced with *home-based*, and the term *clinician-interactive* has been replaced with *office/hospital-based*. The updated terms more accurately reflect the services that they describe and match the terminology used in subsequent publication of the findings of the 2001 evidence report in the peer-reviewed literature.[3, 4]

Store-and-forward telemedicine services collect medical data, store them, and then forward them to be interpreted later. 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 physicians and others to monitor physiologic measurements, test results, images, and sounds, usually collected in a patient's residence 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 also may 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 upload 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 phone or cable television infrastructure to apply two-way interactive video, audio, and medical diagnostic instrumentation. The close monitoring afforded by these approaches may allow better health care through early detection of problems or more precise dosing of medications and biologic agents, potentially reducing costs.

Some common forms of home-based telemedicine services are blood pressure measurement and blood glucose measurement performed by a diabetic patient and used by a clinician to evaluate the patient's glycemic control and to recommend changes in management. Other medical conditions for which home-based telemedicine services have been developed include asthma (in which spirometry is measured), congestive heart failure (weights, symptoms, blood pressure), cardiac arrhythmias (electrocardiography), anticoagulation therapy (prothrombin time), and post-acute hospital care. Monitoring may facilitate preventive measures to be taken before problems get so severe that hospitalization becomes necessary. Telemetry devices could also provide a more cost-effective method of care, by reducing medical visits for conditions that are not severe. Home-based telemedicine systems also may enhance patient-provider communication.

Office/hospital-based telemedicine services are 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.

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 not made definitively, it is often adequate to demonstrate that telemedicine results in *concordant* as opposed to *accurate* decisions. This is particularly true in specialties like dermatology, where diagnoses are made by visualizing skin lesions and not confirmed with definitive testing before treatment is begun. Making accurate decisions usually requires more definitive testing, such as biopsies, which are not routinely done for many conditions, especially those that are not life-threatening.

For this reason, we distinguish in this report between *concordance* and *accuracy* in making diagnoses. We note other dimensions of concordance, such as the measure used (usually either percent agreement or Cohen's kappa measure for categorical data and correlation for continuous data), comparison to the same diagnostician (intraobserver) versus a different one (interobserver), and whether concordance of telemedicine versus face-to-face diagnosis is compared to face-to-face versus face-to-face diagnosis. Studies of the highest quality must include the latter as a reference to the comparison of telemedicine. In our original report, few studies made this important comparison. Accuracy is usually measured by comparison with some gold standard using sensitivity and specificity.

The clinical outcomes assessed in this study are limited to measures of clinical care, such as health status, improvement in clinical parameters (e.g., blood glucose or blood pressure), and recovery from disease. We do not focus on utilization or economic outcomes.

This review has a number of limitations of scope. Our gathering of evidence is limited to the peer-reviewed literature. Only studies assessing populations relevant to Medicare (non-pregnant adults) are assessed. Studies focusing on non-clinical care (teleradiology and telepathology) are excluded, as are those focusing on economics as well as patient or provider satisfaction. We also do not look explicitly at telemedicine from the context of changes in the health care system or implementation of wider information technologies unless such aspects were specifically assessed in peer-reviewed studies.

Other Telemedicine Research Summaries

Several other reports have analyzed the quality of telemedicine studies, some of which are systematic reviews. These include:

Bashshur R, Shannon G, Sapci H. Telemedicine evaluation. 2004. In: Proceedings of the Second International Symposium on the Future Directions for Telemedicine; 2004 May 22-24; Ann Arbor, MI.

Brantley D, Laney-Cummings K, and Spivack R. Innovation, Demand and Investment in Telehealth. 2004, Department of Commerce: Washington, DC. http://www.technology.gov/reports/TechPolicy/Telehealth/2004Report.pdf.

Currell R, et al., Telemedicine versus face-to-face patient care: effects on professional practice and health care outcomes, in The Cochrane Database of Systematic Reviews. 2000, Update Software: Oxford, UK. CD002098.

Grigsby J, Brega A, DeVore P. Health services research and evidence of telemedicine. In: Proceedings of the Second International Symposium on the Future Directions for Telemedicine; 2004 May 22-24; Ann Arbor, MI.

Hailey D, Ohinmaa A, Roine R. Study quality and evidence of benefit in recent assessments of telemedicine. J Telemed Telecare 2004 10(6):318-24.

Heinzelmann P et al. A review of clinical outcomes in telemedicine/telehealth. In: Proceedings of the Second International Symposium on the Future Directions for Telemedicine; 2004 May 22-24; Ann Arbor, MI.

Hersh W, Wallace J, Patterson P, et al. Telemedicine for the Medicare Population. Evidence Report/Technology Assessment No. 24. Rockville, MD: U.S. Department of Health and Human Services, Agency for Health Care Quality and Research. 2001 Jul. AHRQ Publication No. 01-E102.

Jennett P, Scott R, Hailey D, et al. Socio-Economic Impact of Telehealth: Evidence Now for Health Care in the Future: Volume One: State of the Science Report. 2003, Health Telematics Unit, University of Calgary: Calgary, AB.

Chapter 2. Methods

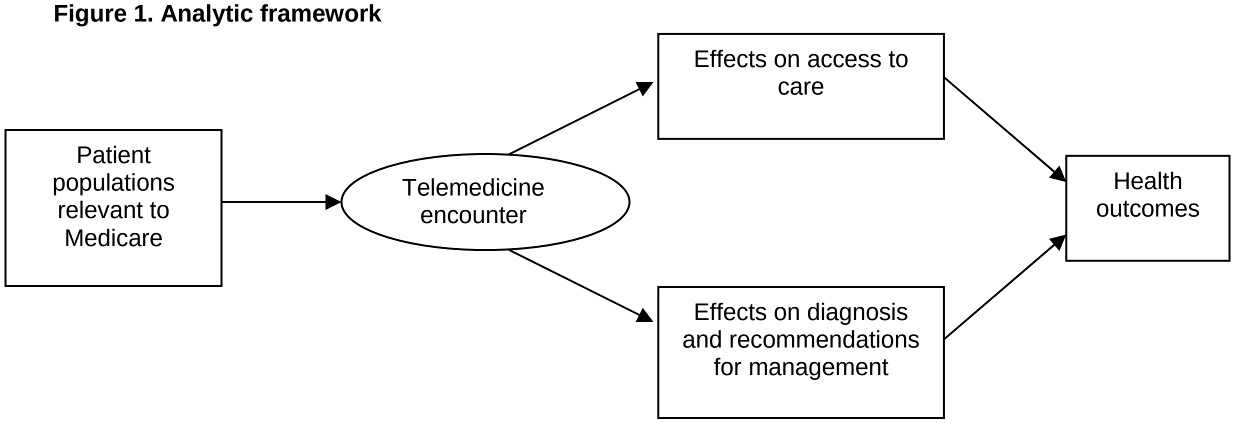
Evidence reports aim to define the limits of the evidence, clarifying when assertions about the value of the intervention are based on strong evidence from clinical studies. The quality of the evidence on effectiveness is a key component, but not the only component, of decision-making on coverage decisions. Both national and local Medicare coverage determinations are also based on whether a service has been determined to be "reasonable and necessary" based on "descriptive information, and scientific and clinical evidence."[5]

The Medicare Payment Advisory Commission has recognized the value that telemedicine services can add to patient care, particularly following the passage of the Medicare, Medicaid, and SCHIP Beneficiary Act of 2000 (BIPA.)[6] However, the potential for overuse of telemedicine services and the need for demonstrated efficacy of telemedicine services prior to making coverage decisions remains an overriding concern.

Analytic Framework and Key Questions about the Efficacy of Telemedicine Services

To determine the key questions and guide the review of the literature in the evaluation of telemedicine, we developed an analytic framework, as shown in Figure 1.

Figure 1. Analytic framework



We then made explicit the key questions for each of the three study areas. For studies of diagnosis and management decisions and of clinical outcomes, the key questions were assessed from the standpoint of determining whether the telemedicine system provided comparable care, since telemedicine can be deemed efficacious when the quality of clinical care provided is as good as, but not necessarily better than, in-person care.

A. Store and forward

1. *Does store-and-forward telemedicine result in comparable diagnostic decisions and recommendations for clinical management?*
2. *Does store-and-forward telemedicine result in comparable 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 comparable diagnostic decisions and recommendations for management?*
2. *Does the use of home-based telemedicine result in comparable 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 comparable diagnosis and appropriateness of recommendations for management?*
2. *Does office/hospital-based telemedicine result in comparable health outcomes?*
3. *Does the availability of office/hospital-based telemedicine improve access to care?*

Literature Search Strategy

We searched the literature for information about ongoing telemedicine programs, activities, and services. This search focused on obtaining English-language journal articles and reports pertaining to the three study areas. We identified programs from the following:

Electronic bibliographic database. The search strategy was similar to that used in the prior report. It 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 associated with the search include *telemedicine*, *remote consultation*, *telecommunications* and *delivery of health care.* Appendix A[*] details the complete search string. The initial search, which identified telemedicine articles published between January 2000 and June 2004, resulted in 3,848 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 MEDLINE® for telemedicine.

Reference lists. Reference lists of previously published telemedicine systematic reviews were searched, resulting in the inclusion of 11 studies to those identified by our search strategy. Of these 11 studies, six were subsequently included following application of the inclusion criteria. Reference lists of included studies also were searched.

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[*] Appendices cited in this report are provided electronically at http://www.ahrq.gov/downloads/pub/evidence/pdf/telemedup/telemedup.pdf.

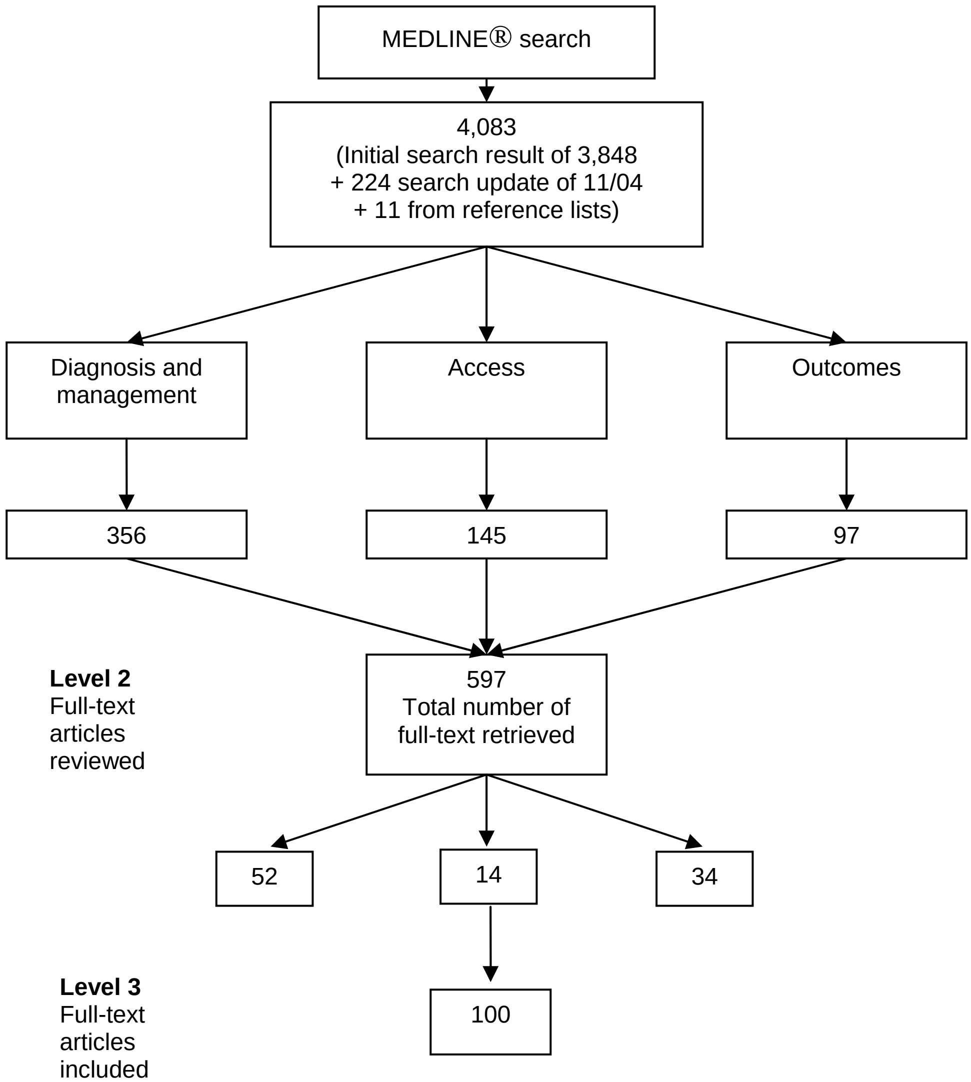
Selection of Abstracts and Full-Text Articles

The results of the literature search and selection of articles for inclusion are shown in Figure 2. All citations were entered into an EndNote® database and were tracked based on inclusion/exclusion status throughout the literature review process.

Four reviewers (WRH, DHH, SMS and TLD) conducted independent screening reviews of all citation titles and abstracts (if available) obtained from the citation acquisition. The citations were dually reviewed. The reviewers read citation titles and abstracts (or titles only if the abstract was not available) 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 address at least one key question in the analytic framework for that study area; and that it contain 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, had a study population that was not relevant to the Medicare population, 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 adaptable to store-and-forward. We excluded reports of telephone care programs and equivalent programs that used electronic mail instead of the telephone, although programs 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 of agreement and kappa 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.

Figure 2. Results of literature search and abstract review



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

Table 1. Inclusion/exclusion criteria

Code #	Explanation
	Inclusion
1	KEY QUESTION AND DATA Addresses a key question on 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	WRONG POPULATION Addresses key question and contains data, but population of study is outside our scope
5	GOOD BACKGROUND MATERIAL and/or REVIEW However, does not meet inclusion criteria
6	OTHER Indicate reason

Table 2. Inter-rater reliability

Reviewers	Percent agreement	Kappa value
WRH, SMS	89.5	.56
WRH, TLD	91.9	.59
DHH, SMS	85.8	.40
DHH, TLD	91.2	.42

Data Abstraction

All studies rated as relevant on the basis of review of titles and abstracts were retrieved, photocopied, and distributed to one of the investigators (WRH or DHH). 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 (Appendix B[1]), and entered into an evidence table. Evidence tables are presented in full in Appendix C.[*] A second investigator reviewed all studies included in evidence tables to verify the evidence table content. The study quality ratings of all included studies were assigned at this time (see further details in the next section). A complete list of excluded studies appears in Appendix D.[*]

Assessment of Study Quality

We critically appraised the included 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.[7] The optimal design for studies of a diagnostic test is different from the optimal design for studies of therapies. For this reason, we used a separate scale to rate the quality of studies that compared the accuracy of "telediagnoses" 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 performance.[8, 9] We paid particular

[1] Appendices cited in this report are provided electronically at http://www.ahrq.gov/downloads/pub/evidence/pdf/telemedup/telemedup.pdf.

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.

Table 3. Classification of evidence for studies of clinical outcomes

Study Class	Characteristic
I	Properly designed random controlled trials
II	Random controlled trials that contain design flaws preventing specification of Class I Properly designed trials with control groups not randomized Multi-center of 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	Characteristic
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

In appraising studies addressing access to care, we adapted criteria described by the Institute of Medicine (IOM)[10] as applied to the use of telemedicine. The model of access to care incorporated three types of indicators: *barriers* (structural, financial, and personal); *utilization*; and *outcomes* (mortality, well-being, 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[7] and had been widely disseminated prior to the period of time covered by the studies reviewed for the current report. Other models of access to care have been described,[11, 12] 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 amount of time for seeking and/or obtaining care.

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

Study Class	Characteristic
I	Appropriately comparable comparison group not exposed to telemedicine services; valid measures of utilization **and** outcomes
II	Appropriately comparable 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

Studies in all categories also were 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 comparable to rather than superior to conventional care. For those studies, the goal was now to determine whether diagnostic and management decisions or clinical outcomes were comparable, rather than determining the directionality of an effect. Studies were classified as clearly comparable when the confidence for measures of association was high and probably comparable 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 current report.

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)

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.

Data Synthesis

Results of the evidence report update are presented in full in the evidence tables (Appendix C[2]). The investigator for each key question constructed separate evidence tables for each of the three study areas. In general, the evidence tables include author/date, key research question(s), study design/level, population, sample/selection, measures, results, quality rating, and limitations.

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

[2] Appendices cited in this report are provided electronically at http://www.ahrq.gov/downloads/pub/evidence/pdf/telemedup/telemedup.pdf.

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 analytic framework links are supported by evidence. We also interpret our synthesis and discuss the limitations of our approach to this evaluation.

Peer Review Process

Thirteen peer reviewers were selected based on their expertise in the field of telemedicine and their availability to review the draft report. Refer to Appendix E[3] for the list of peer reviewers. The draft report was submitted to the peer reviewers along with a peer review form. The review form was developed by the research team and was based on one used in our original study and those used by other research teams at the Oregon Evidence-based Practice Center. The peer reviewers had three weeks to respond. The comments from the peer reviewers were received and distributed to the investigators for their consideration and response. A spreadsheet was prepared that contained the comments of the peer reviewers and our response to them. The peer review comments aided in creating this improved, comprehensive final document.

[3] Appendices cited in this report are provided electronically at http://www.ahrq.gov/downloads/pub/evidence/pdf/telemedup/telemedup.pdf.

Chapter 3. Results

Overview of Peer-reviewed Studies

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.

Table 7. Summary of included studies

	UPDATE				ORIGINAL REPORT			
Modality	**Diagnosis and management**	**Access**	**Outcomes**	**Total**	**Diagnosis and management**	**Access**	**Outcomes**	**Total**
Store and forward	30	5	0	35	22	2	0	24
Home-based	2	0	25	27	4	2	19	25
Office/ hospital-based	20	9	9	38	33	7	6	46
Total	52	14	34	100	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	30	2	3	2	21	2	0		
Diagnosis and management home-based	2	0	0	0	0	2	0		
Diagnosis and management office/hospital-based	20	1	3	1	13	2	0		
Diagnosis and management total	52	3	6	3	34	6	0		
Outcomes store-and-forward	0	0	0	0	0	0	0		
Outcomes home-based	25	6	2	0	17	0	0		
Outcomes office/hospital-based	9	2	0	0	6	1	0		
Outcomes total	34	8	2	0	23	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	100	11	10	4	61	8	0	5	2

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 "comparable" to in-person care, not necessarily "better," especially when it can provide that care with decreased cost, increased convenience, and/or access to care when none was previously available. One way to determine whether two approaches are comparable is to show there is no statistically significant difference between them. However, lack of statistical 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 alpha value (the well-known p value), the value of beta. 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 assessed beta error, and as such, the "statistical comparability" may exist because there was inadequate statistical power to show otherwise.

In assessing diagnostic and management decision studies, 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 the case of concordance studies, a comparison of a "baseline" concordance between two or more face-to-face examiners,
- In the case of accuracy studies, have 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 comparability 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.

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 comparability and did so, or when the study set out to show superiority of telemedicine and did so. Similar to diagnostic and management efficacy studies, Class II studies of outcomes were also not graded higher than B.

Store-and-Forward Telemedicine

Similar to our original evidence report, the studies we found of store-and-forward telemedicine only assessed diagnosis or management decisions and access to care, but not clinical outcomes (Evidence Tables 1 and 2[1]). 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/or interactive interventions. A summary of all studies by medical specialty is shown in Table 9, which

[1] Evidence tables cited in this report are provided electronically at http://www.ahrq.gov/downloads/pub/evidence/pdf/telemedup/telemedup.pdf in Appendix C.

also includes a tally of those from our original report. Studies graded A or B for effect indicate comparability for telemedicine.

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

UPDATE	**Total**	**I-A**	**I-B**	**I-C**	**II-B**	**II-C**	**II-D**	**III-B**	**III-C**
Dermatology	13		2		9	2			
Gastroenterology	2				2				
Gynecology	3			2	1				
Ophthalmology	5	2	1		2				
Plastic Surgery	7				7				
Total	30	2	3	2	21	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	

Also similar to the original report, the largest number of studies came from the specialty of dermatology (Table 9). Of the 13 studies published since the last report, ten 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 intraobserver concordance, while the remainder assessed interobserver concordance.

The most commonly assessed aspect of teledermatology was interobserver concordance.[13-19] The range of concordance varied widely, from 41 percent to 87 percent for complete agreement to 51 percent to 96 percent 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 versus telemedicine agreement with face-to-face versus 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.[20, 21] Concordance studies assessing management decisions typically looked at decision to biopsy. While one study found complete agreement,[22] others found lesser concordance.[13, 23-25]

The studies of diagnostic accuracy typically compared the telemedicine diagnosis to some sort of gold standard, often a biopsy of a pigmented lesion.[13, 23, 26, 27] Most of these studies did not calculate statistical 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 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.[26, 27]

The second most frequently studied clinical area was wound care. Seven studies, all 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 small numbers of patients and very small numbers of clinicians, raising the statistical power issues described above.

Five studies provide data on store-and-forward applications in ophthalmology. Four of these studies show that a high accuracy of diagnosing diabetic retinopathy (DR) could be obtained.[28-31] One of them found, however, that concordance was lower for severity of DR and specific abnormalities.[31]

Other specialties studied include gynecology and gastroenterology. The gynecology studies assessing colposcopy were hindered by the limitations of that procedure even when done in person.[32, 33]

Five studies published in 2000-2004 reported evidence on the effect of store-and-forward techniques upon access to care. The clinical domains of these five studies are summarized in Table 10. Details of the studies' designs and findings are provided in Evidence Table 2.[2] The methodological quality of these studies generally was low.

Table 10. Summary of studies of the effects of store-and-forward telemedicine on access to care

UPDATE	**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	**Total**	**I-B**	**II-B**	**III-B**	**III-C**
Dermatology	2		1		1

The studies of access provide information about how telemedicine systems have been deployed in real-world situations and thereby provide an estimate of the actual clinical impact 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[34, 35] collected no data to assess whether the care provided by the telemedicine service was adequate.

All of the studies that included data on access to care examined the deployment 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[36] used only text information submitted by electronic mail, while the other four studies all 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 percent of patients were recommended to have subsequent face-to-face evaluations by dermatologists.[37, 38] In a randomized trial of all specialty consultation requests in a rural Finnish community, the electronic mail-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 centers providing specialty services.[36]

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[2] Evidence tables cited in this report are provided electronically at http://www.ahrq.gov/downloads/pub/evidence/pdf/telemedup/telemedup.pdf in Appendix C.

The two other studies[34, 35] 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 dermatologic consultation in a Veterans Affairs medical center.[38] 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 favored 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 sooner 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, further distant in time.

Home-Based Telemedicine

In contrast to store-and-forward telemedicine, though similar to our original report, most studies of home-based telemedicine evaluated the clinical outcomes of interventions (see Table 11). Two studies did assess diagnostic capabilities in the home, finding various amounts of agreement and disagreement depending on the observation (see Evidence Table 3[3]). 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 (see Evidence Table 4[*]).

Table 11. Summary of studies of home-based telemedicine for clinical outcomes

UPDATE	Total	I-A	I-B	I-C	II-B	II-C	II-D	III-B
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			

[3] Evidence tables cited in this report are provided electronically at http://www.ahrq.gov/downloads/pub/evidence/pdf/telemedup/telemedup.pdf in Appendix C.

Table 11. Summary of studies of home-based telemedicine for clinical outcomes (continued)

UPDATE	Total	I-A	I-B	I-C	II-B	II-C	II-D	III-B
Psychiatry	1				1			
Pulmonary Medicine	1				1			
Total	25	6	2	0	17	0	0	
ORIGINAL	**Total**	**I-A**	**I-B**	**I-C**	**II-B**	**II-C**	**II-D**	**III-B**
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

A common characteristic of the studies of home-based telemedicine was that the intervention included dedicated staff (usually nursing staff) that monitored the data recorded in the home and developed clinical management plans. Some of the studies were randomized controlled trials that compared such systems (technology and dedicated staff) to 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 discern the benefit of the dedicated program staff from the telemedicine intervention.

While a small number of the studies were well-designed RCTs,[39-43] the rest were limited by either small sample sizes and/or control groups of dubious value. In addition, while all of the studies assessed achieved at least comparable 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 sugar control or weight loss) was not clear.

Three studies of chronic disease in the elderly showed benefit of the dedicated programs in both patient functional status and reduced emergency department visits and hospital admissions.[40-44] Some interventions tailored for specific diseases were found to be effective in congestive heart failure (CHF), hypertension, and pulmonary disease.[39, 42-45] Other home-based interventions, such as blood sugar measurements intended to improve management of diabetes mellitus, were not found consistently superior to usual care.[46-50] Interventions in other domains, such as obesity[51] and lung transplantation,[52] 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. Expanded definitions of access to care, such as “patient-centered access”[11] are applicable to home-based systems and may provide suitable models for future research on the deployment of home-based systems.

Office/Hospital-Based Telemedicine

Studies of office/hospital-based telemedicine provide evidence on diagnosis and management decisions (see Table 12 and Evidence Table 5[4]), clinical outcomes (see Table 13 and Evidence Table 6[*]), and access to care (see Table 14 and Evidence Table 7[*]).

For diagnosis and management decisions, the most commonly studied specialty was ophthalmology. As with store-and-forward studies, some aspects of ophthalmologic evaluation were amenable to interactive telemedicine, while others were not. One Class I study showed rates of disagreement in eye injuries under 10 percent,[53] while another found disagreement was consistently higher with telemedicine than when comparing two in-person evaluations.[54]

Other frequently studied specialties included neurology and psychiatry. Although the studies were rated Class II, two studies showed neurological diagnosis was highly concordant[55, 56] and two studies showed that the NIH Stroke Scale could be reliably administered via telemedicine.[57, 58] A few Class II studies demonstrated concordance on a variety of psychiatric scales.[59-61] Studies in other specialties, such as dermatology,[62] rheumatology,[63] and vascular surgery[64] demonstrated that some diagnostic assessments can be successfully administered interactively via telemedicine.

Table 12. Summary of studies of office/hospital-based telemedicine for diagnosis and/or management decisions

UPDATE	**Total**	**I-A**	**I-B**	**I-C**	**II-B**	**II-C**	**II-D**	**III-B**	**III-C**
Cardiology	2				2				
Dermatology	1				1				
Gastroenterology	1				1				
Neurology	4				4				
Ophthalmology	5		1	1	1	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	**Total**	**I-A**	**I-B**	**I-C**	**II-B**	**II-C**	**II-D**	**III-B**	**III-C**
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

Studies of clinical outcomes also showed that for most of the clinical specialties assessed, outcomes between conventional and telemedicine interventions were

[4] Evidence tables cited in this report are provided electronically at http://www.ahrq.gov/downloads/pub/evidence/pdf/telemedup/telemedup.pdf in Appendix C.

comparable. However, most of these studies were limited by small sample sizes (with the caveats concerning statistical significance described earlier), lack of randomization, and assessment of less than the full range of clinical outcomes. None of these studies attempted to measure statistical power to avoid beta error. Class I RCTs showing comparable outcomes were done in otolaryngology[65] and psychiatry.[66]

Table 13. Summary of studies of office/hospital-based telemedicine for clinical outcomes

UPDATE	Total	I-A	I-B	I-C	II-B	II-C	II-D	III-B
Critical Care	1				1			
Neurology	1					1		
Orthopedics	2				2			
Otolaryngology	1	1						
Psychiatry	3	1			2			
Wound Care	1				1			
Total	9	2	0	0	6	1	0	
ORIGINAL	**Total**	**I-A**	**I-B**	**I-C**	**II-B**	**II-C**	**II-D**	**III-B**
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

The studies of access have examined the use of office-based telemedicine in both suburban and rural settings and have examined both specialist evaluations and follow-up continuity care. In limited studies of patients with sickle cell anemia[67] and patients with chronic psychiatric disorders,[68] office-based telemedicine appeared to be adequate for the ongoing routine care of patients in rural areas, with few problems reported. For new evaluations by specialists of patients referred by general practitioners, the use of office-based telemedicine led to a significantly greater rate of diagnostic test utilization than face-to-face consultations for neurology patients[69] but not for patients needing other types of specialty care.[70, 71] Two studies compared office-based telemedicine to telephone consultations between a referring physician and a specialist.[63, 72] Both these studies had weak designs but had results suggesting that the telemedicine system provided faster access to definitive care.

Table 14. Summary of studies of the effect of office/hospital-based telemedicine on access to care

UPDATE	Total	I-B	I-C	II-B	II-C	III-B
Neurology	2				1	1
Orthopedics/Rheumatology	3	1		1		1
Ophthalmology	1					1
Multiple specialties	1		1			
Psychiatry	1			1		
Hematology	1			1		
Total	9	1	1	3	1	3
ORIGINAL	**Total**	**I-B**	**I-C**	**II-B**	**II-C**	**III-B**
Neurosurgery	3			2		1
Cardiology	2					2
Multiple specialties	2					2
Total	7	0	0	2	0	5

Studies of Telemedicine in Non-Medicare Populations

A total of 28 studies identified in the literature search were excluded from consideration for evidence tables because they were conducted in populations not eligible for Medicare services based on their demographic characteristics. All of these 28 studies were considered to have evidence potentially applicable to the key questions on the basis of the initial title and abstract review. The populations examined in these studies included children, pregnant women, incarcerated prisoners, and active duty military personnel. These studies were subjected to further review, and twelve were deemed to have evidence suitable for inclusion in evidence tables if we had not applied the population exclusion. Seven of the studies examined home-based telemedicine, three examined store-and-forward techniques, and two examined office-based telemedicine applications. The studies' findings were consistent with the findings of the studies included in the evidence tables. We concluded that excluding studies conducted on non-Medicare populations had not biased our overall conclusions.

Chapter 4. Discussion

Evidence about Efficacy

This update on evidence about the efficacy of telemedicine for the Medicare population covered published peer-reviewed literature for the five years between 2000 and 2004. Similar to the findings of our original report a half-decade ago, there are still serious gaps in the evidence base for telemedicine. While this situation is hardly unique to telemedicine, having a solid evidence base is essential given that there is increased advocacy for health care payers, especially Medicare, to provide coverage for its use. In the discussion that follows, we will review telemedicine by specialty in the case of store-and-forward and office/hospital-based telemedicine and by disease domain in the case of home-based 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. Various psychiatric and neurological assessments can be administered effectively via interactive videoconferencing. Likewise, treatments administered in these specialties via telemedicine appear to achieve comparability with face-to-face care. It can probably be concluded that medical care administered via interactive 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 methodologic quality, showing 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 integrated systems is unlikely to be beneficial. Systems designed to facilitate specific aspects of care, such as blood sugar and blood pressure measurements, provide less clear benefit. With ongoing improvements in telecommunications technology, particularly broadband connections to the home, further research, including larger clinical trials, will likely be informative.

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 this report is consistent with the findings of the earlier report. There continues to be highly variable rates of interobserver and intraobserver agreement in diagnoses. This issue can only be resolved by high-quality studies that compare not only the concordance of telemedicine versus face-to-face diagnosis, but also the concordance of face-to-face versus face-to-face diagnosis in the same situation. It should be noted that the teleophthalmology field has done this in most of their 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 deployed 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. Thus, it appears that the expense and time commitment of teledermatology systems have not yet demonstrated the potential for improving access to care.

Of course, rates of concordance in a vacuum, i.e., without a 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 comparable care for the patient? A corollary question that must be answered 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 were identified in this report. One study has been completed (personal communication, J Whited), but at the time of this writing has not yet been submitted for publication. In general, advocacy for an expanded role for teledermatology will require further studies that examine rates of missed diagnoses, incorrect treatments, and when the technology is insufficient to avoid in-person encounters.

Most published studies of teledermatology have examined store-and-forward techniques, with relatively few studies of real-time office-based techniques. 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. Dermatologic practice also involves follow-up visits of patients who have previously received a comprehensive dermatologic 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 also may be a useful adjunct in dermatologic consultations for settings in which patients are located a great distance from the consultant (such as isolated rural settings). The published studies suggest that a fraction of such patients may successfully avoid face-to-face visits to complete the dermatologic evaluation.

Teleophthalmology has been widely studied, and this field has produced commercial systems for retinal photographs that are becoming widely used as a clinical tool to augment face-to-face evaluations of patients at risk for diabetic retinopathy.[73] The quality of studies in this domain is slightly higher than in dermatology, although the results are equivocal. Essentially, teleophthalmology results in high rates of diagnostic concordance and accuracy for only 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. The value of a technology that is only useful for some conditions must be assessed in the larger picture of clinical outcomes and ultimately the economics of investing in equipment that is not always useful.

Also widely studied is the use of telemedicine for wound care. The key observation from studies assessing telemedicine for this purpose is that all of the studies have small sample sizes, use only one assessor, and do not compare in-person examiners when assessing concordance. These studies present a trend of comparability, but serious questions remain about their statistical power and reproducibility.

The situation of gynecology, in particular telecolposcopy, is also instructive. Studies show that the accuracy of diagnosis by telemedicine is comparable to face-to-face assessment. However, the accuracy of neither of these approaches is terribly efficacious, in the range of 50-60 percent.

An often-touted benefit of telemedicine is the provision of care to rural areas, where specialists are less prevalent and individuals in need of them 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 continuity care of stable patients by specialists. The technological platform for such systems is relatively uncomplicated and can be based on widely available teleconferencing equipment.

In general, the role of telemedicine most likely to demonstrate value could be as an adjunct to care that is centered around the in-person visit. As noted above, it could, for example, serve as a means to triage skin lesions, injuries, and other problems that arise where appropriate specialty care is not available. In most instances, clinical care will likely still require in-person diagnosis and management. Likewise, telemedicine may also play a role in managing the growing number of elderly and other infirmed individuals with chronic diseases. Its value may not be as a substitute for in-person care as much as an adjunct to it.

Experience with telemedicine has similarities to other attempts to apply computer technology to clinical environments. Computer-based expert systems went through a long period of experimental evaluation and limited deployment, and systems designed to enhance (or even replace) clinician judgment were found to be best suited to narrow clinical domains.[74-76] Nevertheless, the use of computer-based decision support has steadily increased, as it has been more appropriately integrated into the clinical care process, serving more as an assistant than a replacement of clinical judgment and expertise.[77] Well-designed and definitive clinical trials of this type of decision support have enhanced the adoption of the technology.[78,79]

As noted in Chapter 1, this review is limited in scope to the peer-reviewed literature of telemedicine. While this spectrum of data does not cover all or even most of the experience with telemedicine, it does provide the most objective, evidence-based assessment of this technology. The presence of a small number of well-designed studies with positive outcomes that our analysis identified shows that it is possible to demonstrate efficacy of telemedicine.

Of course, there may be situations when the use of telemedicine is warranted even if the evidence is lacking. For example, there may be situations when care would be otherwise impossible to deliver except via telemedicine. 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 setting where it can be obtained. However, even in these instances it is important to understand the efficacy of telemedicine so any clinical shortcomings can be anticipated. We are reassured that no studies show telemedicine to cause any significant harm.

We also acknowledge that the efficacy of telemedicine is not immune to other forces in health care, such as the structure of the delivery system. There are instances when reimbursement or other incentives are not amenable to innovations, technical or otherwise. In particular, fee-for-service health care will likely provide incentive for modalities of care that are reimbursed, not necessarily those that provide the best quality care. Therefore it will be important for ongoing research to take into account the health care setting when evaluating the efficacy of telemedicine.

Future Research

The present evidence base provides guidance on the clinical areas in which future research is most likely to be useful. It now is clear that continued small or methodologically weak studies are unlikely to add to the evidence base for telemedicine. In teledermatology, 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. Well-designed RCTs will likely provide valuable information on the potential of these clinical applications. Longitudinal observational studies and demonstration projects also will be useful. Studies of home-based telemedicine should carefully address the independent contributions of technology and human resources in the complex delivery models for patients with chronic diseases.

We recognize the limitations of advice that telemedicine be studied with more and larger RCTs. Not only are such trials expensive, but they are difficult to carry out. They also have a long lead-time from their planning and inception to completion and analysis of results. Another challenge with RCTs in this area is that telemedicine is not a single technology or intervention. It is a tool that is used to deliver different aspects of clinical care for diverse diseases. Due to the time and expense of RCTs, other means to assess telemedicine interventions objectively should also be explored. Given the growing use of electronic health records, selective data could be extracted on patients with telemedicine interventions to assess them longitudinally. Such studies will be most feasible in large integrated delivery networks with advanced electronic health record systems.

This report has found that the evidence base for telemedicine is incomplete yet improving. Further well-designed and targeted research that provides high-quality data will provide a strong contribution to understanding how best to deploy technological resources in health care.

Conclusion

The promise of telemedicine is not matched by the strength of its evidence base. The technology to administer telemedicine is prevalent and, in some locations, ubiquitous. Telemedicine is widely used, with increasing numbers of health care payers reimbursing for its use. However, outside of a small number of clinical specialties, the evidence base for the efficacy of telemedicine is weak. Areas where telemedicine is most promising include home health and specialties where care can be delivered via interactive videoconferencing, such as psychiatry and neurology. There is mixed evidence for the efficacy of telemedicine in dermatology and ophthalmology. Further research must address the limited evidence base so that the optimal use of telemedicine can be ascertained.

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Appendix A: Exact 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

Appendix B. Sample Data Abstraction Forms

Store-and-forward telemedicine:

1. Sample data abstraction form for studies of diagnosis and management for store-and-forward telemedicine

Source	Specialty	Purpose	Gold standard	Sample	Diagnosis (D) and/or management (M) decisions	Limitations	Study Class

2. Sample data abstraction form for studies of access for store-and-forward telemedicine

Source	Purpose/ design	Intervention	Control	Measure of access	Population/ sample	Results	Limitations	Study Class

Home-based telemedicine:

3. Sample data abstraction form for studies of diagnosis and management for home-based telemedicine

Source	Domain	Purpose	Gold standard	Sample	Diagnosis (D) and/or management (M) decisions	Limitations	Study Class

4. Sample data abstraction form for studies of health outcomes for home-based telemedicine

Source	Domain	Question	Study type	Control	Sample	Results	Limitations	Study Class

Office/hospital-based telemedicine

5. Sample data abstraction form for studies of diagnosis and management for office/hospital-based telemedicine

Source	Specialty	Purpose	Gold standard	Sample	Diagnosis (D) and/or management (M) decisions	Limitations	Study Class

6. Sample data abstraction form for studies of access for office/hospital-based telemedicine

Source	Purpose/ design	Intervention	Control	Measure of access	Population/ sample	Results	Limitations	Study Class

7. Sample data abstraction form for studies of health outcomes for office/hospital-based telemedicine

Source	Specialty	Question	Study type	Control	Sample	Results	Limitations	Study Class

Appendix C. Evidence Tables

Evidence table 1: Studies of diagnosis and management for store-and-forward telemedicine……………………………………………………………………..……..A-5

Evidence table 2: Studies of access for store-and-forward telemedicine……………..A-12

Evidence table 3: Studies of diagnosis and management for home-based telemedicine ………………………………………………………………………………...A-14

Evidence table 4: Studies of health outcomes for home-based telemedicine…………A-15

Evidence table 5: Studies of diagnosis and management for office/hospital-based telemedicine…………………………………………………………………...A-21

Evidence table 6: Studies of health outcomes for office/hospital-based telemedicine..A-25

Evidence table 7: Studies of access for office/hospital-based telemedicine…………..A-27

Listing of included studies……………………………………………………….A-33

Evidence table 1: Studies of diagnosis and management for store-and-forward telemedicine

Source	Specialty	Purpose	Sample	Number of TM clinicians	Diagnosis or Management	Concordance	FTF v FTF concordance	Accuracy	Study class
Barnard, 2000	Dermatology	Diagnostic agreement in all patients; accuracy of diagnosis in those with definitive diagnostic test	50 cases, 25 confirmed by dx testing	8	Both	For 50 cases, 77% (range 67-84%) for primary dx and 90% (range 84-96%) for diff dx; decision to biopsy 40% for FTF vs. 45% for TM	No	For 25 cases, 84% FTF vs. 73% TM; for 8 cancers, 88% FTF vs. 90% TM	II-B
Coras, 2003	Dermatology	Diagnostic agreement of teledermatoscopy	100 cases of pigmented lesions using teledermato-scopy, 45% of which were biopsied	3	Diagnosis			For 45 cases, 91.1% FTF vs. 88.8% TM	I-B
DuMoulin, 2003	Dermatology	Diagnostic agreement for TM	106 cases referred by GP	1	Diagnosis	54% full agreement, 9% partial agreement (diff dx), and 37% no agreement	No		II-C
Eminovic, 2003	Dermatology	Diagnostic agreement for patients seen via TM vs. FTF	96 cases referred by GP	12	Diagnosis	41% full agreement, 10% partial agreement (diff dx), and 49% no agreement	No		II-C
Jolliffe, 2001, BJD	Dermatology	Decision by GP to triage pigmented lesions for TM assessment	819 lesions assessed for referral	5	Management	For decision to refer, sens = 88% and spec = 66%; intraobserver kappa = 0.48	No		II-B

Evidence table 1: Studies of diagnosis and management for store-and-forward telemedicine (continued)

Source	Specialty	Purpose	Sample	Number of TM clinicians	Diagnosis or Management	Concordance	FTF v FTF concordance	Accuracy	Study class
Jolliffe, 2001, CED	Dermatology	Comparison of pigmented lesions diagnosed by TM vs. FTF	144 lesions assessed histologically	NS	Diagnosis			For 144 lesions, 43% FTF vs. 47% TM; no malignancies missed	I-B
Lim, 2001	Dermatology	Diagnostic agreement for TM for primary and diff dx	53 cases from 49 patients	4	Diagnosis	Self concordance vs. FTF 88%; concordance for 4 other derms 79% (range 73-85%)	No		II-B
Oztas, 2003	Dermatology	Diagnostic agreement for TM with pictures alone and clinical information added	125 patients referred	3	Diagnosis	Agreement of TM was 55-58% without clinical information, 69-87% with clinical information	No		II-B
Pak, 2003 (2 studies)	Dermatology	Intraobserver diagnostic agreement for TM	404 patients referred	1	Both	Intraobserver (TM followed by FTF) agreement was 70% complete, 20.6% partial, and 9.4% none; for partial or no agreement, clinical significance was moderate 41.3% and severe 0.8%; biopsy rates false positive 17.1% and false negative 6.9%	No		II-B

Evidence table 1: Studies of diagnosis and management for store-and-forward telemedicine (continued)

Source	Specialty	Purpose	Sample	Number of TM clinicians	Diagnosis or Management	Concordance	FTF v FTF concordance	Accuracy	Study class
Piccolo, 2002	Dermatology	Diagnostic agreement with teledermoscopy	43 cases of pigmented lesions	8	Diagnosis			91% FTF vs. 79-95% TM	II-B
Rashid, 2003	Dermatology	Diagnostic agreement for TM	26 skin conditions in 33 patients	1	Diagnosis	81% agreement and 19% disagreement	No		II-B
Shapiro, 2004	Dermatology	Decision to perform a skin biopsy by FTF dermatologist	49 patients with pigmented lesions	1	Management	100% agreement on decision to biopsy	No		II-B
Taylor, 2001	Dermatology	Agreement for TM diagnosis and decision to make referral	194 patients assessed 13 months after actual visit	2	Diagnosis	Agreement of TM was 77%; no difference between intra and interobserver	No		II-B
Kim, 2000	Gastroenterology	Accuracy of GI endoscopy transmitted by video	5 patients for upper GI endoscopy, 5 patients for lower GI endoscopy – observed by TM	1	Diagnosis	100% agreement on all diagnoses but G-E junction not seen clearly on 2 upper GI endoscopies	No		II-B
Wildi, 2004	Gastroenterology	Diagnostic quality of remote GI endoscopy	50 patients undergoing GI endoscopy	1	Diagnosis			For major lesions, sens = 98%, spec = 80%	II-B

Evidence table 1: Studies of diagnosis and management for store-and-forward telemedicine (continued)

Source	Specialty	Purpose	Sample	Number of TM clinicians	Diagnosis or Management	Concordance	FTF v FTF concordance	Accuracy	Study class
Etherington, 2002	Gynecology	Diagnostic agreement in telecolposcopy	81 women undergoing colopscopy	1	Diagnosis	For normal vs. abnormal, 91.4% agreement; for normal vs. low-grade CIN vs. high-grade CN, 79.0% agreement	No		II-B
Ferris, 2002, OG	Gynecology	Diagnostic agreement in telecolposcopy	186 women undergoing cervical biopsy after colposcopy (also interactive)	2	Both	Agreement for biopsy was 67.4% for site experts vs. interactive TM, 73.3% for local vs. site experts, 84.1% for local vs. interactive TM, and 72.6 for TM vs. S&F TM, comparable to decisions for endocervical curettage	Yes	Accuracy for local colposcopists 59.7%, local experts 52.7%, immediate TM 55.7%, later TM 49.7%	I-C
Ferris, 2002, JFP	Gynecology	Sensitivity of telecolposcopy and remote cervicography	264 women undergoing cervical biopsy after colposcopy	3	Diagnosis			Accuracy with histology varied from 56.9% for local colopscopists to 52.4-55.5% for various types of TM	I-C

Evidence table 1: Studies of diagnosis and management for store-and-forward telemedicine (continued)

Source	Specialty	Purpose	Sample	Number of TM clinicians	Diagnosis or Management	Concordance	FTF v FTF concordance	Accuracy	Study class
Baker, 2004	Ophthalmology	Accuracy of different levels of JPEG compression for findings and management decisions in diabetic retinopathy (DR)	20 diabetic patients with images compressed 55x and 113x	1	Diagnosis	Agreement varied for retinal abnormalities from kappa = 0.45-1.0, for level of retinopathy from 0.73-1.0, and for management recommendation follow-up from 0.64-1.0	No		II-B
Gomez-Ulla, 2002	Ophthalmology	Agreement in detection and grading of DR	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	Ophthalmology	Agreement in grading DR	70 diabetic patients and controls assessed with various digital photography and handheld digital video (DV) camera	3	Diagnosis			Sens/spec best for red-free imaging (97.7%/98.9%), worst for DV (6.9%/50%)	I-A
Shiba, 2002	Ophthalmology	Accuracy of fundus photography for DR	61 diabetic patients assessed with digital photography for DR	1	Diagnosis			Sens/spec for best digital photography was 82.1%/100%	I-B

Evidence table 1: Studies of diagnosis and management for store-and-forward telemedicine (continued)

Source	Specialty	Purpose	Sample	Number of TM clinicians	Diagnosis or Management	Concordance	FTF v FTF concordance	Accuracy	Study class
Yogesan, 2000	Ophthalmology	Agreement in TM screening	43 subjects assessed with digital indirect ophthalmoscope (DIO) and handheld 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 was 0.76	No		II-B
Braun, 2005	Wound Care	Wound assessment using new generation mobile telephone cameras	61 wounds in 52 patients	3	Diagnosis	Agreement vs. FTF varied from kappa = 0.74-0.82 for TM physicians	No		II-B
Gardner, 2001	Wound Care	Accuracy of chronic wound assessments	13 wound observations	1	Diagnosis	Agreement on 8 characteristics was 75-100% but only 54% on presence of epithelial tissue	No		II-B
Halstead, 2003	Wound Care	Management decisions in wound care for 4 yes/no decisions	17 individuals with 20 wounds	1	Management	Agreement on management decisions averaged 89%	No		II-B
Houghton, 2000	Wound Care	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 interrater correlation was 73%	No		II-B

Evidence table 1: Studies of diagnosis and management for store-and-forward telemedicine (continued)

Source	Specialty	Purpose	Sample	Number of TM clinicians	Diagnosis or Management	Concordance	FTF v FTF concordance	Accuracy	Study class
Jones, 2003	Wound Care	Reliability of images to assess burn wounds	60 burn wounds assessed with different resolution digital photographs	1	Diagnosis	Intraobserver kappa was 0.53-0.60	No		II-B
Jones, 2004	Wound Care	Agreement of injury severity and operative priority in minor injuries requiring plastic surgery consultation	82 trauma referrals	3	Both	Correlation for grade of injury 0.78-0.81 and for operative priority 0.87-0.93	No	(Correlation on categorical data!)	II-B
Kim, 2003	Wound Care	Accuracy of chronic wound assessments	430 visits on 70 patients	NS	Diagnosis	Agreement for not healing was 67.1%, necrosis 77.0%, cellulitis 88.8%, osteomyelitis 72.5%, and not closed 96.7%	No		II-B

Evidence table 2: Studies of access for store-and-forward telemedicine

Source	Purpose/ Design	Intervention	Control	Measure of access	Population/ sample	Results	Limitations	Study class
Whited, 2002	Evaluate system for screening dermatology referrals in a VA medical center 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 61.3 years N = 275	Median time was 41 days in teledermatology group and 127 days in control group. 18.5% of teledermatology patients had definitive evaluation made by teledermatology.	Dermatology clinic had a substantial appointment backlog that likely exaggerated the difference between groups.	I-B
Mallett, 2003	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 electronic mail	None	Rate of subsequent face-to-face visits at dermatology clinic	Patients seen in offices of general practitioners in UK; age range 4 months to 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	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 electronic mail	None	Consulting surgeons' judgment 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 electronic mail review were not re-evaluated face-to-face	III-B

Evidence table 2: Studies of access for store-and-forward telemedicine (continued)

Source	Purpose/ Design	Intervention	Control	Measure of access	Population/ sample	Results	Limitations	Study class
Jaatinen, 2002	Compare results of specialty consultations conducted by electronic mail between physicians or by conventional visits in specialty clinics Prospective randomized trial	Textual information provided by general practitioner using a web site. Consultant could ask for further information by electronic mail sent to the general practitioner	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 general practitioners 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.	General practitioners could choose not to randomize patients if they preferred a face-to-face visit.	II-B
Tennant, 2000	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 center to undergo review by retinal specialist	None	Follow-up care of screened patients	Patients with diabetes identified by general practitioners in remote Canadian community; mean age 55.4 years N = 100	10% of patients were referred for laser photocoagulation	No information on prevalence of diabetes in the community or previous rates of screening	III-B

Evidence table 3: Studies of diagnosis and management for home-based telemedicine

Source	Domain	Purpose	Sample	Number of TM clinicians	Diagnosis or management	Concordance	FTF v FTF concordance	Accuracy	Study class
Jenkins, 2001	Congestive heart failure (CHF)	Agreement in findings of CHF patients by home health nurses	28 home care patients with CHF	1	Diagnosis	Of 18 items assessed, TM more likely to claim nail color abnormality and real-time nurse more likely to detect inspiratory wheeze, ankle edema, and pedal edema	No		II-C
Morlion, 2002	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

Evidence table 4: Studies of health outcomes for home-based telemedicine

Source	Domain	Question	Study type	Control	Sample	Results	Limitations	Class
Artinian, 2003	CHF	Does the medication compliance device Med-eMonitor monitoring improve care?	RCT	9 patients with usual care	9 patients with usual care plus compliance device and web-based monitoring	No change in behaviors, 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	CHF	Does nurse telemanagement by advanced practice nurse and vital sign monitoring improve outcomes?	RCT	108 patients with nurse home visit	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	CHF	Does home monitoring of vital signs and video consulting improve care?	RCT	10 patients with usual care	10 patients with home telemonitoring	Comparable weight, blood pressure, and quality of life.	Small sample size.	II-B
Jerant, 2001	CHF	Does home videoconferencing plus electronic auscultation improve care?	RCT	12 patients in usual care	13 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
LaFramboise, 2003	CHF	Does HealthBuddy telecommunication device improve care?	RCT	23 patients with home visit, 26 with telephonic	21 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

Evidence table 4: Studies of health outcomes for home-based telemedicine (continued)

Source	Domain	Question	Study type	Control	Sample	Results	Limitations	Class
Roth, 2004	CHF	Does home monitoring of vital signs improve care?	Pre-post	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 factors other than telemedicine could have influenced outcome	II-B
Chumbler, 2004	Chronic disease in elderly	Does HealthBuddy, monitoring of vital signs, and videoconferencing improve cognitive and other function?	Prospective case control	115 case-matched veterans referred from senior agencies or rehabilitation programs	111 veterans enrolled in home telemonitoring project	Improvements in instrumental activities of daily living and functional independence measurement scales.	No randomization, groups may have differences.	II-B
Kobb, 2003	Chronic disease in elderly	Does HealthBuddy, monitoring of vital signs, and videoconferencing improve cognitive and other function?	Cohort	1120 patients receiving usual care	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 differences.	II-B
Noel, 2004	Chronic disease in elderly	Does monitoring of vital signs directly into EHR improve quality of life and cognitive function?	RCT	57 veterans	47 veterans	Statistically significant reduction in bed days of care, urgent visits, HgbA1c, OARS cognitive status and functional level.	Many other measures showed no difference.	I-A

Evidence table 4: Studies of health outcomes for home-based telemedicine (continued)

Source	Domain	Question	Study type	Control	Sample	Results	Limitations	Class
Ades, 2000	Coronary artery disease	Does EKG and transtelephonic monitoring provide comparable outcomes for at-home cardiac rehabilitation?	Cohort	50 patients receiving usual care	83 patients	Exercise capacity, quality of life, and complications (none) comparable in both groups	No randomization, groups may have differences.	II-B
Barnarson, 2003	Coronary artery disease	Does HealthyBuddy monitoring improve care?	RCT	18 patients with Health Buddy asking series of questions	17 patients with routine care	Communication intervention group had higher self-efficacy, comparable risk factor adherence, and better functional outcomes per SF-36.	Relatively small sample size.	I-A
Bellazzi, 2003	DM	Does home glucose monitoring and videoconferencing improve outcomes?	Cohort	67 users of diabetes telemedicine system	62 non-users of system	HgbA1C differences not significant but less variance in experimental group.	No randomization, groups may have differences.	II-B
Biermann, 2002	DM	Does home glucose monitoring improve outcomes?	RCT	16 patients with conventional care	27 patients with home glucose monitoring	Both groups had comparable drops in HgbA1C levels.	Small sample size, unexplained uneven distribution into groups.	II-B
Izquierdo, 2003	DM	Does diabetes education delivered by telemedicine improve outcomes?	RCT	22 patients with education delivered in-person	24 patients with education delivered via telemedicine	No change in HgbA1C or behavior goals between groups.		I-B

Evidence table 4: Studies of health outcomes for home-based telemedicine (continued)

Source	Domain	Question	Study type	Control	Sample	Results	Limitations	Class
Welch, 2003	DM	Does home glucose monitoring improve outcomes?	RCT	26 patients who used modem-equipped glucometers	26 patients who received usual care	Slightly larger drop in HgbA1C for experimental group but not significant	Results obtained from Montori paper, over half of subjects lost to follow-up at 12 months	II-B
Montori, 2004	DM	Does home glucose monitoring with feedback improve outcomes?	RCT	16 patients with glucometer transmission plus nurse feedback	15 patients with glucometer transmission but no feedback	Statistically significant reduction in HgbA1C (8.2 vs. 7.8%), 50 more minutes per patient in phone time for experimental group		I-A
Artinian, 2001	Hypertension	Does home monitoring and community-based monitoring of blood pressure improve care?	RCT	9 patients with usual care	6 patients with home telemonitoring and 6 with community-based monitoring	Drop in BP for both experimental groups statistically significant over control group.	Small sample size, short (3-month) follow-up.	II-B
Bondmass, 2000	Hypertension	Does home monitoring of blood pressure improve care?	Pre-post	33 patients with uncontrolled hypertension >1 year	Same 33 patients after invention	Statistically significant reduction in blood pressure from average of 154/90 to 141/83	Pre-post design means factors other than telemedicine could have influenced outcome	II-B

Evidence table 4: Studies of health outcomes for home-based telemedicine (continued)

Source	Domain	Question	Study type	Control	Sample	Results	Limitations	Class
Rogers, 2001	Hypertension	Does home monitoring of blood pressure improve care?	RCT	55 patients with usual care	56 patients with home telemonitoring	Better improvement in mean, systolic, and diastolic pressure (mmHg) for home telemedicine (-2.8,-4.9,-2.0) vs. control (+1.3,-0.1,+2.1).	Clinical significance of improvements in blood pressure not clear.	I-A
Mullan, 2003	Lung transplantation	Does monitoring by home electronic symptom diary improve outcomes in patients awaiting lung transplant?	RCT	52 patients with telephone reporting	67 patients uploading electronic diary	Adherence, length of stay in hospital after transplant, and survival after transplant identical.	Few clinical parameters assessed.	II-B
Egner, 2003	Multiple sclerosis	Does telerehabilitation program delivered via video or phone improve care?	RCT (subgroup analysis)	7 patients with in-person and 11 patients with phone rehabilitation	9 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	Newly injured spinal cord patients	Does video-based rehabilitation improve care?	RCT	39 patients with standard intervention, 36 with telephone intervention	36 patients with video intervention	Video intervention group had significantly higher Quality of Well-Being scale at one year and reduced annual hospital days		I-A

Evidence table 4: Studies of health outcomes for home-based telemedicine (continued)

Source	Domain	Question	Study type	Control	Sample	Results	Limitations	Class
Harvey-Berino, 2002	Obesity	Does therapist-led Internet support group lead to better weight loss?	RCT	15 patients in control group, 14 patients in therapist-led in-person group	15 patients in therapist-led Internet group	Amount of weight loss comparable in all groups.	Small sample size.	II-B
D'Souza, 2002	Psychiatry	Does a psycho-educational program by videoconference after inpatient discharge improve care?	Cohort	27 patients discharged to conventional care	24 patients discharged to care plus program	Telemedicine patients had higher adherence, lower readmission, and lower medication side effects.	No randomization, groups may have differences.	II-B
Maiolo, 2003	Pulmonary Disease	Does home monitoring of pulmonary status of pulmonary status improve care?	Pre-post	23 patients with home monitoring of pulmonary function	Same patients after intervention	Statistically 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

Evidence table 5: Studies of diagnosis and management for office/hospital-based telemedicine

Source	Specialty	Purpose	Sample	Number of TM clinicians	Diagnosis or management	Concordance	FTF v FTF concordance	Accuracy	Study class
Scalvini, 2002	Cardiology	Remote diagnosis of chest pain by GP	952 ECG diagnoses made by TM	NS	Diagnosis			Sens/spec of service was 97.4%/89.5%	I-B
Terkelsen, 2002	Cardiology	Prehospital diagnosis in ambulances	250 patients for prehospital diagnosis of acute MI	NS	Diagnosis			Sens/PPV for acute MI was 88%/56%	I-B
Nordal, 2001	Dermatology	Agreement in diagnosis via videoconference	121 patients referred to dermatologist	2	Diagnosis	Agreement was 72% complete and 14% partial	No		II-B
Craig, 2000, EJN	Neurology	Agreement of neurologic inpatient assessment	25 neurology inpatients	1	Diagnosis			23 of 25 diagnoses correct by interactive videoconferencing	II-B
Craig, 2000, JTT	Neurology	Agreement of neurologic outpatient assessment	25 neurology outpatients	1	Diagnosis			24 or 25 diagnoses correct by interactive videoconferencing	II-B
Handschu, 2003	Neurology	Agreement of stroke assessment via NIH Stroke Scale (NIHSS)	41 patients receiving NIH Stroke Scale (NIHSS) in setting of acute stroke	NS	Diagnosis	Agreement on 13 elements varied from 0.44-0.89 on unweighted kappa and from 0.85-0.99 when weighted per accepted protocol	No		II-B
Wang, 2003	Neurology	Accuracy of stroke assessment using NIH Stroke Scale (NIHSS)	20 patients receiving NIHSS in setting of acute stroke	4	Diagnosis	Correlation of score for TM vs. FTF was 0.96	No		II-B

Evidence table 5: Studies of diagnosis and management for office/hospital-based telemedicine (continued)

Source	Specialty	Purpose	Sample	Number of TM clinicians	Diagnosis or management	Concordance	FTF v FTF concordance	Accuracy	Study class
Bowman, 2003	Ophthalmology	Accuracy of eye injury assessment	80 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 used.	Yes		I-B
Crowston, 2004	Ophthalmology	Measurements in trabeculectomized eyes using telemedicine vs. in-person	40 trabeculectomized eyes in 40 patients	3	Diagnosis	For 6 measures, agreement always higher in FTF vs. FTF than TM vs. FTF	Yes		I-C
Dawson, 2002	Ophthalmology	Assessment of strabismus	30 patients with strabismus	2	Diagnosis	Agreement was complete 80%, partial 3%, and incomplete 17%	No		II-B
Rayner, 2001	Ophthalmology	Agreement of ophthalmic adnexal exam	17 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

Evidence table 5: Studies of diagnosis and management for office/hospital-based telemedicine (continued)

Source	Specialty	Purpose	Sample	Number of TM clinicians	Diagnosis or management	Concordance	FTF v FTF concordance	Accuracy	Study class
Smith, 2003	Ophthalmology	Slit lamp assessment via telemedicine	12 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	Otolaryngology	Agreement in audiometry testing	45 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	Otolaryngology	Accuracy of otolarynology consultation	Intraobserver concordance for assessment of 42 patients	1	Diagnosis			For first 20 patients, diagnosis incorrect in 8; for next 22 patients, all diagnoses correct	II-B
Menon, 2001	Psychiatry	Psych 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 20.7% FTF/27.9% TM (NS), for HAM-D was 27.7% FTF/30.8% TM (NS), and for SPMSE was 63.3% FTF/31.6% TM (p=.02)	No		II-B

Evidence table 5: Studies of diagnosis and management for office/hospital-based telemedicine (continued)

Source	Specialty	Purpose	Sample	Number of TM clinicians	Diagnosis or management	Concordance	FTF v FTF concordance	Accuracy	Study class
Shores, 2004	Psychiatry	Neuropsychiatric evaluation via telemedicine	16 patients screening positive for dementia on 7-minute screen	NS	Diagnosis	100% agreement on presence of dementia (in 12 patients)	No		II-B
Yoshino, 2001	Psychiatry	Agreement in Brief Psychiatric Rating Scale administration	42 patients with chronic schizophrenia interviewed by FTF and viewed by narrowband and broadband	NS	Diagnosis	Agreement was 87% FTF vs. FTF, 88% FTF vs. broadband TM, 44% FTF vs. narrowband TM (p<.05)	Yes		I-A
Leggett, 2001	Rheumatology	Accuracy of rheumatology consultation	100 patients referred to a rheumatologist	1	Diagnosis			Accuracy of diagnosis was 97% for TM, 71% for telephone	I-B
Endean, 2001	Vascular Surgery	Agreement of treatment recommendations for vascular surgery patients seen via telemedicine	64 vascular abnormalities in 32 patients	1	Management	Agreement with treatment recommendations was 91%	No		II-B

Evidence table 6: Studies of health outcomes for office/hospital-based telemedicine

Source	Specialty	Question	Study type	Control	Sample	Results	Limitations	Study Class
Breslow, 2004	Critical Care	Does supplemental remote ICU monitoring improve outcomes of care?	Pre-post	1396 patients before telemedicine intervention	744 patients after intervention	Telemedicine reduced mortality (RR=0.73), length of stay (3.63 days vs. 4.35 days), and variables costs per case	Pre-post design means factors other than telemedicine could have influenced outcome	II-B
Chua, 2001	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	76 patients evaluated by telemedicine, 65 patients evaluated by in-person care	In-person patients had fewer neuro (6/82 vs. 26/86) and non-neuro (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	Orthopedics	Does telerehabilitation for total knee replacement have comparable outcomes?	RCT	11 patients randomized to conventional care	10 patients who had weekly treatment for 6 weeks	No difference in physical or functional measurements.	Small sample, short follow-up.	II-B
Vuolio, 2003	Orthopedics	Is video-conferencing aided by GP and nurse as effective as traditional clinic?	RCT	69 patients seen in outpatient clinic	76 patients seen in health center by videoconference	Equal fulfillment of patient management plans.	Focus mainly on process and not clinical outcomes.	II-B
Mashima, 2003	Otolarngology	Can voice therapy be delivered as effectively by telemedicine as in person?	RCT	28 patients with conventional voice therapy	23 patients with videoconference voice therapy	Both groups improved, with no differences between them.		I-A

Evidence table 6: Studies of health outcomes for office/hospital-based telemedicine (continued)

Source	Specialty	Question	Study type	Control	Sample	Results	Limitations	Study Class
Bouchard, 2004	Psychiatry	Can cognitive-behavior therapy for panic disorder be delivered via telemedicine?	Cohort	11 patients with video-conferencing	10 patients with face to face care	Both groups had comparable improvement in reduction in panic attacks and scores on Beck Depression Inventory.	Small sample, no randomization.	II-B
Kennedy, 2003	Psychiatry	Do patients using telepsychiatry have comparable health outcomes to in-person care?	Cohort	92 patients who did not have telepsychiatry	32 patients who had telepsychiatry	No difference in Health of the Nation Outcome Scale or Mental Health Inventory.	No randomization, likely differences between experimental and control groups.	II-B
Ruskin, 2004	Psychiatry	Is telepsychiatry treatment (medications, education, brief supportive counseling) comparable to face to face treatment?	RCT	60 patients treated with face to face treatment	59 patients treated with telepsychiatry	Equal outcomes in both groups for Hamiltion Depression Rating Scale and Beck Depression Inventory.		I-A
Wilbright, 2004	Wound Care	Is telemedicine treatment comparable to in-person treatment?	Cohort	120 patients treated conventionally	20 patients treated via interactive telemedicine	No differences in healing time or percent healed	No randomization, likely differences between experimental and control groups.	II-B

Evidence table 7: Studies of access for office/hospital-based telemedicine

Source	Purpose/ Design	Intervention	Control	Measure of access	Population/ sample	Results	Limitations	Study class
LaMonte, 2003	Evaluate system for screening patients with symptoms of stroke seen in emergency department 100 miles from stroke treatment center Comparison of telemedicine cases to concurrent cases managed by telephone consultation	2-way audio-video link; consultant neurologist interviews and examines stroke patient by telemedicine.	Telephone discussion between emergency department physician and consultant neurologist.	Percentage 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 to 4% of 27 traditional consultations	An undetermined number of the control group patients were ineligible for fibrinolytic therapy.	III-B
Woods, 2000	Evaluate system for providing follow-up care to patients with sickle cell anemia living more than 100 miles from university clinic Before/after study of clinic workload	2-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 anemia; 84% Medicaid insurance N=128 in post-telemedicine period	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

Evidence table 7: Studies of access for office/hospital-based telemedicine (continued)

Source	Purpose/ Design	Intervention	Control	Measure of access	Population/ sample	Results	Limitations	Study class
Haukipuro, 2000	Evaluate satisfaction with a system for routine orthopedic clinic visits Randomized trial of patients referred to a university orthopedic clinic in Finland	2-way audio-video link; orthopedic 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 orthopedic specialist	Orthopedic patients; mean age 56.7 years. N = 145	Overall satisfaction rated as very good or good in 80% or telemedicine encounters and 89% of conventional encounters	No measures of clinical outcomes	II-B
Vuolio, 2003	Evaluate treatment plans of newly referred orthopedic patients examined via a telemedicine system Randomized trial of patients referred to a university orthopedic clinic in Finland.	2-way audio-video link; orthopedic 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.	Orthopedic 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

Evidence table 7: Studies of access for office/hospital-based telemedicine (continued)

Source	Purpose/ Design	Intervention	Control	Measure of access	Population/ sample	Results	Limitations	Study class
Wallace, 2002	Measure whether a telemedicine system to conduct initial specialist evaluations reduces rates of diagnostic test utilization and subsequent face-to-face encounters Randomized trial of patients referred by general practitioners to specialists in London, UK	2-way audio-video link; both general practitioner and specialist participate in teleconference with patient.	Face-to-face encounter between patient and specialist	Orders for follow-up face-to-face appointments and diagnostic tests	Patients seen in offices of general practitioners 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 appointment rates were higher for surgical specialty consultations that for medical specialty consultations. Telemedicine patients had fewer tests ordered.	No measures of actual clinical outcomes	I-C
Leggett, 2001	Compare telephone-based consultation to video-based methods for providing rheumatologic consultations Comparison of successive telephone and video-based consultations on same patients	Patient interview by rheumatologist using desktop videoconferencing system	Telephone conversation between general practitioner and rheuma-tologist	Physician opinion of need to see patient face-to-face following teleconsulta-tion	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

Evidence table 7: Studies of access for office/hospital-based telemedicine (continued)

Source	Purpose/ Design	Intervention	Control	Measure of access	Population/ sample	Results	Limitations	Study class
Kennedy, 2003	Compare psychiatric consultations delivered by videoconferencing to care of similar patients delivered face-to-face Non-randomized prospective control-group design	Interview conducted by video-conferencing 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 general practitioner 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

Evidence table 7: Studies of access for office/hospital-based telemedicine (continued)

Source	Purpose/ Design	Intervention	Control	Measure of access	Population/ sample	Results	Limitations	Study class
Chua, 2002	Compare management plans of patients undergoing neurologic evaluation by teleconference or by face-to-face evaluation Prospective randomized trial of newly referred patients. Additional non-randomized comparison of 4 other patient cohorts.	Consulting neurologist interviewed patient and reviewed radiologic images placed on view box at telemedicine site. Physical examination conducted by assistant at the telemedicine site.	Conventional clinic visits staffed by neurologists or general practitioners	Percentage of patients receiving appointments for further testing or follow-up appointments	Adult patients presenting to general practitioners with neurologic complaints (mean age 34.8 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 general practitioners had significantly higher rates of tests and follow-up appointments when compared to the teleconsultation patients.	Comparability of patients seen by general practitioners is not well described.	II-C

Evidence table 7: Studies of access for office/hospital-based telemedicine (continued)

Source	Purpose/ Design	Intervention	Control	Measure of access	Population/ sample	Results	Limitations	Study class
Taylor, 2003	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	Judgment 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

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Appendix D: Listing of Excluded Studies

Aarnio P, Jaatinen P, Hakkari K, et al. A new method for surgical consultations with videoconference. Annales Chirurgiae et Gynaecologiae 2000 89(4):336-40.
Excluded - contains no or inadequate data

Aarnio P, Rudenberg H, Ellonen M, et al. User satisfaction with teleconsultations for surgery. J Telemed Telecare 2000 6(4):237-41.
Excluded - does not meet our definition of telemedicine

Aas IH. A qualitative study of the organizational consequences of telemedicine. J Telemed Telecare 2001 7(1):18-26.
Excluded - contains no or inadequate data

Abbott KC, Mann S, DeWitt D, et al. Physician-to-physician consultation via electronic mail: the Walter Reed Army Medical Center Ask a Doc system. Mil Med 2002 Mar; 167(3):200-4.
Excluded - does not meet our definition of telemedicine

Abdoh AA, Krousel-Wood MA and Re RN. Accuracy of telemedicine in detecting uncontrolled hypertension and its impact on patient management. Telemed J E Health 2003 Winter; 9(4):315-23.
Excluded - does not address a key question

Abrahamian H, Schueller A, Mauler H, et al. Transfer of knowledge from the specialist to the generalist by videoconferencing: effect on diabetes care. J Telemed Telecare 2002 8(6):350-5.
Excluded - contains no or inadequate data

Agha Z, Schapira RM and Maker AH. Cost effectiveness of telemedicine for the delivery of outpatient pulmonary care to a rural population. Telemed J E Health 2002 Fall; 8(3):281-91.
Excluded - does not address a key question

Albisser AM. Clinical studies with home glucose clamping. Ann Endocrinol (Paris) 2001 Feb; 62(1 Pt 1):11-8.
Excluded - no comparison group

Alessi NE. Quantitative documentation of the therapeutic efficacy of adolescent telepsychiatry. Telemed J E Health 2003 Fall; 9(3):283-9.
Excluded - contains no or inadequate data

Amir O and Shabtai E. Public information services in the field of communication disorders: comparison between teleservice and E-service. Telemed J E Health 2002 Winter; 8(4):369-75.
Excluded - does not address a key question

Andersson G, Lundstrom P and Strom L. Internet-based treatment of headache: does telephone contact add anything? Headache 2003 Apr; 43(4):353-61.
Excluded - does not meet our definition of telemedicine

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Excluded - contains no or inadequate data

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Excluded - does not address a key question

Anonymous. Sacramento hospital boosts outcomes by focusing on high-risk CHF patients. Data Strategies & Benchmarks 2001 May; 5(5):68-7, 65.
Excluded - contains no or inadequate data

Anonymous. CHF managers make the case for home-monitoring technology. Dis Manag Advis 2002 Oct; 8(10):156-8, 145.
Excluded - does not address a key question

Anonymous. Demo produces stunning results in care of complex patients. Clinical Resource Management 2002 Feb; 3(2):21-5.
Excluded - contains no or inadequate data

Anonymous. Study suggests video visits have significant cost, quality benefits. Dis Manag Advis 2002 Mar; 8(3):44-7, 33.
Excluded - contains no or inadequate data

Anonymous. Online doctor-patient communication tool saves time on phone. Perform Improv Advis 2003 Mar; 7(3):37-9.
Excluded - does not address a key question

Appel PR, Bleiberg J and Noiseux J. Self-regulation training for chronic pain: can it be done effectively by telemedicine? Telemed J E Health 2002 Winter; 8(4):361-8.
Excluded - contains no or inadequate data

Aris IB, Wagie AA, Mariun NB, et al. An internet-based blood pressure monitoring system for patients. J Telemed Telecare 2001 7(1):51-3.
Excluded - no comparison group

Arthur HM, Smith KM, Kodis J, et al. A controlled trial of hospital versus home-based exercise in cardiac patients. Med Sci Sports Exerc 2002 Oct; 34(10):1544-50.
Excluded - does not address a key question

Aucar J, Granchi T, Liscum K, et al. Is regionalization of trauma care using telemedicine feasible and desirable? American Journal of Surgery 2000 180(6):535-9.
Excluded - does not address a key question

Axford AT, Askill C and Jones AJ. Virtual multidisciplinary teams for cancer care. J Telemed Telecare 2002 8(Suppl 2):3-4.
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Excluded - does not address a key question

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Excluded - no comparison group

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Excluded - does not address a key question

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Banerjee S, Steenkeste F, Couturier P, et al. Telesurveillance of elderly patients by use of passive infra-red sensors in a 'smart' room. J Telemed Telecare 2003 9(1):23-9.
Excluded - does not meet our definition of telemedicine

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Excluded - wrong population

Baruffaldi F, Gualdrini G and Toni A. Comparison of asynchronous and realtime teleconsulting for orthopaedic second opinions. J Telemed Telecare 2002 8(5):297-301.
Excluded - contains no or inadequate data

Beach M, Goodall I and Miller P. Evaluating telemedicine for minor injuries units. J Telemed Telecare 2000 6(1)
Excluded - no comparison group

Bellazzi R, Larizza C, Montani S, et al. A telemedicine support for diabetes management: the T-IDDM project. Comput Methods Programs Biomed 2002 Aug; 69(2):147-61.
Excluded - does not address a key question

Bellon E, Aerts W, Vanautgaerden M, et al. Web-access to a central medical record to improve cooperation between hospital and referring physicians. Studies in Health Technology & Informatics 2002 93:145-53.
Excluded - does not address a key question

Belmont JM and Mattioli LF. Accuracy of analog telephonic stethoscopy for pediatric telecardiology. Pediatrics 2003 Oct; 112(4):780-6.
Excluded - wrong population

Benger J, Lock A, Cook J, et al. The effect of resolution, compression, colour depth and display modality on the accuracy of accident and emergency telemedicine. J Telemed Telecare 2001 7(Suppl 1):6-7.
Excluded - does not address a key question

Bennett SJ, Hays LM, Embree JL, et al. Heart Messages: a tailored message intervention for improving heart failure outcomes. Journal of Cardiovascular Nursing 2000 14(4):94-105.
Excluded - does not meet our definition of telemedicine

Berendt M, Schaefer B, Heglund MJ, et al. Telehealth for effective disease state management. Home Care Provid 2001 Apr; 6(2):67-72.
Excluded - does not address a key question

Berg BW, Vincent DS and Hudson DA. Remote critical care consultation: telehealth projection of clinical specialty expertise. J Telemed Telecare 2003 9(Suppl 2):S9-11.
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Excluded - contains no or inadequate data

evaluation. Journal of the American Academy of Dermatology 2000 42(5 Pt 1):770-5.
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Excluded - does not address a key question

Bishop JE, O'Reilly RL, Maddox K, et al. Client satisfaction in a feasibility study comparing face-to-face interviews with telepsychiatry. J Telemed Telecare 2002 8(4):217-21.
Excluded - does not address a key question

Blomdahl S, Calissendorff B and Jacobsson U. Patient-focused urban tele-ophthalmology services. J Telemed Telecare 2002 8(Suppl 2):43-4.
Excluded - contains no or inadequate data

Blomdahl S, Maren N and Lof R. Tele-ophthalmology for the treatment in primary care of disorders in the anterior part of the eye. J Telemed Telecare 2001 7(Suppl 1):25-6.
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Bose U, McLaren P, Riley A, et al. The use of telepsychiatry in the brief counselling of non-psychotic patients from an inner-London general practice. J Telemed Telecare 2001 7(Suppl 1):8-10.
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Boukhors Y, Rabasa-Lhoret R, Langelier H, et al. The use of information technology for the management of intensive insulin therapy in type 1 diabetes mellitus. Diabetes Metab 2003 Dec; 29(6):619-27.
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Bove P, Stoianovici D, Micali S, et al. Is telesurgery a new reality? Our experience with laparoscopic and percutaneous procedures. J Endourol 2003 Apr; 17(3):137-42.
Excluded - does not address a key question

Bowater M. The experience of a rural general practitioner using videoconferencing for telemedicine. J Telemed Telecare 2001 7(Suppl 2):24-5.
Excluded - contains no or inadequate data

Bracale M, Cesarelli M and Bifulco P. Telemedicine services for two islands in the Bay of Naples. J Telemed Telecare 2002 8(1):5-10.
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Braun RP, Meier M, Pelloni F, et al. Teledermatoscopy in Switzerland: a preliminary

Brebner EM and Brebner JA. Implementation and evaluation of telemedicine for remote health-care--the European Northern Periphery Programme Project. J Telemed Telecare 2001 7(Suppl 1):68-9.
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Brebner JA, Brebner EM, Ruddick-Bracken H, et al. The development of a pilot telemedicine network in Scotland: lessons learned. J Telemed Telecare 2001 7(Suppl 2):83-4.
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Bremner F, Kennedy C, Rees A, et al. Usefulness of teleconsultations in neuro-ophthalmology. J Telemed Telecare 2002 8(5):305-6.
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Brennan DM, Georgeadis AC, Baron CR, et al. The effect of videoconference-based telerehabilitation on story retelling performance by brain-injured subjects and its implications for remote speech-language therapy. Telemed J E Health 2004 Summer; 10(2):147-54.
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Brennan PF, Moore SM, Bjornsdottir G, et al. HeartCare: an Internet-based information and support system for patient home recovery after coronary artery bypass graft (CABG) surgery.[see comment]. J Adv Nurs 2001 Sep; 35(5):699-708.
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Brenner B. Is the provision of laboratory results via the Internet acceptable to patients? A survey of private patients in a large, specialist gynaecology practice. N Z Med J 2003 Dec 12; 116(1187):U711.
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Brian J and Jamieson S. Post-surgical cardiac patients receive new level of care. Caring 2002 Mar; 21(3):28-9.
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Broderick TJ, Harnett BM, Doarn CR, et al. Real-time Internet connections: implications for surgical

decision making in laparoscopy. Ann Surg 2001 Aug; 234(2):165-71.
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Brodey BB, Claypoole KH, Motto J, et al. Satisfaction of forensic psychiatric patients with remote telepsychiatric evaluation. Psychiatr Serv 1305 51(10):1305-7.
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Brown-Connolly NE. Patient satisfaction with telemedical access to specialty services in rural California. J Telemed Telecare 2002 8(Suppl 2):7-10.
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Brownrigg P, Lowry JC, Edmondson MJ, et al. Telemedicine in oral surgery and maxillofacial trauma: a descriptive account. Telemed J E Health 2004 Spring; 10(1):27-31.
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Burgess LP, Syms MJ, Holtel MR, et al. Telemedicine: teleproctored endoscopic sinus surgery. Laryngoscope 2002 Feb; 112(2):216-9.
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Bursell SE, Cavallerano JD, Cavallerano AA, et al. Stereo nonmydriatic digital-video color retinal imaging compared with Early Treatment Diabetic Retinopathy Study seven standard field 35-mm stereo color photos for determining level of diabetic retinopathy. Ophthalmology 2001 Mar; 108(3):572-85.
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Buurke JH, Kleissen RF, Nene A, et al. A feasibility study of remote consultation to determine suitability for surgery in stroke rehabilitation. J Telemed Telecare 2004 10(2):108-12.
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Bynum A, Hopkins D, Thomas A, et al. The effect of telepharmacy counseling on metered-dose inhaler technique among adolescents with asthma in rural Arkansas. Telemed J E Health 2001 Fall; 7(3):207-17.
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Byrne JP and Mughal MM. Telementoring as an adjunct to training and competence-based assessment in laparoscopic cholecystectomy. Surgical Endoscopy 1159 14(12):1159-61.
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Cabrera MF, Arredondo MT and Quiroga J. Integration of telemedicine into emergency medical services. J Telemed Telecare 2002 8(Suppl 2):12-4.
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Cadiere GB, Himpens J, Vertruyen M, et al. Evaluation of telesurgical (robotic) NISSEN fundoplication. Surgical Endoscopy 2001 Sep; 15(9):918-23.
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Car J and Sheikh A. Email consultations in health care: 1--scope and effectiveness. Bmj 2004 Aug 21; 329(7463):435-8.
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Car J and Sheikh A. Email consultations in health care: 2--acceptability and safe application. Bmj 2004 Aug 21; 329(7463):439-42.
Excluded - does not address a key question

Cargill A and Watson AR. Telecare support for patients undergoing chronic peritoneal dialysis. Perit Dial Int 2003 Jan-Feb; 23(1):91-4.
Excluded - does not address a key question

Cathala N, Brillat F, Mombet A, et al. Patient followup after radical prostatectomy by Internet medical file. J Urol 2003 Dec; 170(6 Pt 1):2284-7.
Excluded - does not address a key question

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 Apr; 23(2):215-23.
Excluded - no comparison group

Cavan DA, Everett J, Plougmann S, et al. Use of the Internet to optimize self-management of type 1 diabetes: preliminary experience with DiasNet. J Telemed Telecare 2003 9(Suppl 1):S50-2.
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Cavina E, Goletti O, Lippolis PV, et al. Telesonography: technical problems, solutions and results in the routine utilization from remote areas. Studies in Health Technology & Informatics 2001 81:88-9.
Excluded - does not address a key question

Cawthorpe D. An evaluation of a computer-based psychiatric assessment: evidence for expanded use. Cyberpsychol Behav 2001 Aug; 4(4):503-10.
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Cervi PL and Everitt AS. Automatic voice mail for delivering computer-generated anticoagulant dose advice to patients. J Telemed Telecare 2002 8(5):259-63.
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Chae YM, Heon Lee J, Hee Ho S, et al. Patient satisfaction with telemedicine in home health services for the elderly. Int J Med Inf 2001 May; 61(2-3):167-73.
Excluded - does not address a key question

Chae YM, Park HJ, Cho JG, et al. The reliability and acceptability of telemedicine for patients with schizophrenia in Korea. J Telemed Telecare 2000 6(2):83-90.
Excluded - does not address a key question

Chambers M and Connor S. Technology as an aid to coping with caring: a usability evaluation of a telematics intervention. Medinfo 2001 10(Pt 2):1130-4.
Excluded - does not meet our definition of telemedicine

Chambers M and Connor SL. User-friendly technology to help family carers cope. J Adv Nurs 2002 Dec; 40(5):568-77.
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Chambers MG, Connor SL, McGonigle M, et al. Multimedia software to help caregivers cope. J Am Med Inform Assoc 2003 Sep-Oct; 10(5):504-11.
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Chan DS, Callahan CW, Sheets SJ, et al. An Internet-based store-and-forward video home telehealth system for improving asthma outcomes in children. Am J Health Syst Pharm 2003 Oct 1; 60(19):1976-81.
Excluded - wrong population

Chan WM, Woo J, Hui E, et al. The role of telenursing in the provision of geriatric outreach services to residential homes in Hong Kong. J Telemed Telecare 2001 7(1):38-46.
Excluded - contains no or inadequate data

Chao LW, Cestari TF, Bakos L, et al. Evaluation of an Internet-based teledermatology system. J Telemed Telecare 2003 9(Suppl 1):S9-12.
Excluded - contains no or inadequate data

Chao LW, Enokihara MY, Silveira PS, et al. Telemedicine model for training non-medical persons in the early recognition of melanoma. J Telemed Telecare 2003 9(Suppl 1):S4-7.
Excluded - contains no or inadequate data

Chase HP, Pearson JA, Wightman C, et al. Modem transmission of glucose values reduces the costs and need for clinic visits.[see comment]. Diabetes Care 2003 May; 26(5):1475-9.
Excluded - wrong population

Chen K, Lim A and Shumack S. Teledermatology: influence of zoning and education on a clinician's ability to observe peripheral lesions. Australas J Dermatol 2002 Aug; 43(3):171-4.
Excluded - contains no or inadequate data

Chen RS and Chen SK. Teledentistry using videoconferencing and a DICOM image management system. J Telemed Telecare 2002 8(4):244-6.
Excluded - contains no or inadequate data

Cherry JC, Dryden K, Kobb R, et al. Opening a window of opportunity through technology and coordination: a multisite case study. Telemed J E Health 2003 Fall; 9(3):265-71.
Excluded - contains no or inadequate data

Cherry JC, Moffatt TP, Rodriguez C, et al. Diabetes disease management program for an indigent population empowered by telemedicine technology. Diabetes Technol Ther 2002 4(6):783-91.
Excluded - does not address a key question

Chetney R. The Cardiac Connection program: home care that doesn't miss a beat. Home Healthc Nurse 2003 Oct; 21(10):680-6.
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Cheung JC, Dick PT, Kraft SP, et al. Strabismus examination by telemedicine. Ophthalmology 1999 107(11):1999-2005.
Excluded - wrong population

Choremis J and Chow DR. Use of telemedicine in screening for diabetic retinopathy.[see comment]. Can J Ophthalmol 2003 Dec; 38(7):575-9.
Excluded - no comparison group

Chua R, Craig J, Wootton R, et al. Cost implications of outpatient teleneurology. J Telemed Telecare 2001 7(Suppl 1):62-4.
Excluded - does not address a key question

Cipolat C, Bader U, Rufli T, et al. Teledermatology in Switzerland. Aktuelle Probl Dermatol 2003 32:257-60.
Excluded - contains no or inadequate data

Clement PF, Brooks FR, Dean B, et al. A neuropsychology telemedicine clinic. Mil Med 2001 May; 166(5):382-4.
Excluded - contains no or inadequate data

Clifton GD, Byer H, Heaton K, et al. Provision of pharmacy services to underserved populations via remote dispensing and two-way videoconferencing. Am J Health Syst Pharm 2003 Dec 15; 60(24):2577-82.

Excluded - does not address a key question

Collins K, Bowns I and Walters S. General practitioners' perceptions of asynchronous telemedicine in a randomized controlled trial of teledermatology. J Telemed Telecare 2004 10(2):94-8.
Excluded - contains no or inadequate data

Collins K, Walters S and Bowns I. Patient satisfaction with teledermatology: quantitative and qualitative results from a randomized controlled trial. J Telemed Telecare 2004 10(1):29-33.
Excluded - does not address a key question

Collins PW, Bolton-Maggs P, Stephenson D, et al. Pilot study of an Internet-based electronic patient treatment record and communication system for haemophilia, Advoy.com. Haemophilia 2003 May; 9(3):285-91.
Excluded - does not address a key question

Cone SW, Gehr L, Hummel R, et al. Case report of remote anesthetic monitoring using telemedicine. Anesth Analg 2004 Feb; 98(2):386-8, table of contents.
Excluded - contains no or inadequate data

Constable IJ, Yogesan K, Eikelboom R, et al. Fred Hollows lecture: digital screening for eye disease. Clinical & Experimental Ophthalmology 2000 28(3):129-32.
Excluded - does not address a key question

Cook DJ, Doolittle GC and Whitten PS. Administrator and provider perceptions of the factors relating to programme effectiveness in implementing telemedicine to provide end-of-life care. J Telemed Telecare 2001 7(Suppl 2):17-9.
Excluded - does not address a key question

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