**Title:** Asynchronous telehealth: Systematic review of analytic studies

Amol Deshpande, MD, MBA1

Shariq Khoja, MD, PhD2

Julio Lorca, MD3

Ann McKibbon, BSc, MLS, PhD4

Carlos Rizo, MD, PhD 5

Alejandro R. Jadad, MD, DPhil, FRCPC6

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1Consultant, Foresight Links Corporation, Toronto, Ontario, Canada [amol.d@rogers.com]

2Assistant Professor, Dept of Community Health Sciences and Medical Director's Office, Aga Khan University, Karachi, Pakistan [shariq.khoja@aku.edu]

3General Director, Institute for Innovation on Human Well-being, Malaga, Andalusia, Spain

4Associate Professor (Part-Time), Health Information Research Unit, Faculty of Health Sciences, McMaster University [mckib@mcmaster.ca]

5Candidate, Department of Health Policy, Management and Evaluation, University of Toronto, Toronto, Ontario, Canada [crizos@gmail.com]

6Professor, Chief Innovator and Founder of the Centre for Global eHealth Innovation, University Health Network and University of Toronto, Toronto, Ontario, Canada [ajadad@ehealthinnovation.org]

**Authorship**

Amol Deshpande (AD) led the research; and coordinated the project, including the design of data extraction tables, supervision of data extraction, confirmation of final selected trials, preparation of initial draft of the review, and participation in subsequent report revisions.

Alejandro R. Jadad (AJ) conceived the project, developed the initial protocol, assisted in data extraction, and participated in all phases of report writing.

Carlos Rizo (CR) extracted and tabulated data for the environmental scan and assisted in report writing.

Ann McKibbon (AM) and Shariq Khoja (SK) selected trials and studies, extracted and tabulated data, and reviewed the final report.

Julio Lorca prepared the initial draft of the asynchronous telehealth environmental scan.

All authors contributed to the revisions of the report.

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The authors declare that they have no financial or non-financial conflict of interest.

**ABSTRACT**

**Background**

Asynchronous telehealth allows the digital capture of relevant material in one location and its interpretation at a remote site by health professionals. Its utility and position in the health care system, however, still remains poorly defined. This review attempts to fill this gap.

**Objectives**

To determine the impact of asynchronous telehealth on health outcomes, process of care, access to health services, and health resources

**Methods**

A search was performed up to December 2006 of MEDLINE, CINAHL, HealthSTAR, the Database of Abstracts of Reviews of Effectiveness and The Cochrane Library. Studies were included if they contained original data on any modality of asynchronous telehealth and were published in English in a peer-reviewed journal. Two independent reviewers screened all articles and extracted data, reaching consensus on the articles and data identified. Data were extracted on general study characteristics, clinical domain, technology, setting and category of outcome and results. Summary data was presented qualitatively.

**Results**

The systematic review included 52 original studies from 238 citations identified, with almost half focused on teledermatology. Included studies were characterized by diverse designs, interventions, and outcomes. Only 16 studies were judged to be of high quality. Most studies showed beneficial effects in terms of diagnostic accuracy, wait times, referral management, and satisfaction with services. Evidence on the impact of asynchronous telehealth on resource use in dermatology suggests a reduction in the number of or avoidance of in-person visits. Reports from other clinical domains also described the avoidance of unnecessary transfer of patients.

**Conclusions**

Although the quality of many original studies in asynchronous telehealth remains poor, there is consistent evidence suggesting that this telehealth modality could lead to shorter wait times, fewer unnecessary referrals, high levels of patient and provider satisfaction, and equivalent (or better) diagnostic accuracy when compared with face-to-face consultations.

# INTRODUCTION

Canada’s access to technology and the need to deliver services to remote and underserved communities has been the main impetus for driving the expansion of telemedicine programs. Telehealth services that rely on real-time consultations, however, are realizing that their need for participants to interact from dedicated, specialized facilities is limited by similar problems that affect traditional consultations, particularly the need to schedule face-to-face encounters between patients and health professionals. Telehealth programs may need to consider a shift in a model that continues to rely on a physician’s real-time presence, which is a scarce commodity given changing demographics and the lifestyle choices of physicians. 1,2

A modality of telehealth, known as asynchronous (or store-and-forward) telehealth, helps provide administrative and support services to areas that lack health professionals to meet the needs of the population in situ. Because of the widespread penetration of the internet, personal digital assistants (PDAs), and smart phones (voice-centric handheld devices that function as phones and as PDAs); the reduction in cost of data storage; and the proliferation of digital cameras, patients and health professionals can capture clinically important digital samples and relevant data (e.g., pictures of moles or surgical wounds, electrocardiograms (EKGs), spirometry results, radiological images) from any location and send them to health professionals at distant sites for assessment at a convenient time. Its independence from real-time interactions between patients and health professionals and the low cost of the required infrastructure, could allow asynchronous telehealth to reduce wait times, provide opportunities to re-think the way in which high-demand services are organized, optimize the use of limited health resources, and promote equitable access to health professionals and services.

So far, clinical applications of asynchronous telehealth have not received the same degree of attention as real-time telehealth.3 This qualitative systematic review addresses the impact of asynchronous telehealth on health outcomes, health delivery services, health care resource use and user satisfaction.

## Methods

A protocol, which is available from the corresponding author, was written a priori and followed throughout the review process. Article screening and data extraction were performed using TrialStat SRS 4.0 (Ottawa ON).

### **Literature search strategy**

An information specialist (ME) prepared a detailed search strategy (Appendix 1) combining three clusters of terms: the first focused on telehealth, the second on asynchronous modalities, and the third on health services delivery. Electronic searches, performed up to mid-December 2006, included the following databases: MEDLINE (from 1966), CINAHL (from 1982), HealthSTAR (from 1975), the Database of Abstracts of Reviews of Effectiveness (DARE), and The Cochrane Library. The yield from the bibliographic databases was complemented with a scan of reference lists from eligible reports.

### **Selection method**

An article was regarded as potentially eligible if it met all the following criteria.

* Evaluated one or more clinical asynchronous services.
* Involved the capture of digital clinical samples by physicians, community-based nurses, or trained members of the public.
* Focused on the delivery of digital samples for assessment by specialists at separate locations, transferred electronically.
* Included data on health outcomes, process of care, resource utilization, or user satisfaction.
* Appeared in an English-language, peer-reviewed journal, since 1995.

Studies on clinical asynchronous telehealth were excluded if they focused only on diagnostic concordance among different methods (i.e., no other outcome data presented) or on technical issues (e.g., different modalities of telehealth or telehealth versus face-to-face consultations).

Two teams of reviewers [team 1 (AM and CL), team 2 (SK and HD)] independently screened each title and abstract of a potentially eligible report. Two of the authors (ARJ and AD) resolved any discrepancies between the teams by independently reviewing each title and abstract or if necessary, the full report. If disagreement persisted, a final decision was reached by consensus between ARJ and AD.

### **Data extraction and abstraction strategy**

Both teams of reviewers extracted data independently, using unmasked copies of the reports. Where disagreements existed, the final set was reviewed independently by ARJ and AD. Any differences were resolved by consensus.

A standard data extraction form was used to collect the following information from each report:

* General characteristics (e.g., name of lead author, publication title, year of publication, country of study)
* Study type [e.g., observational (i.e., non-experimental), experimental, or descriptive]; if observational, it was recorded whether it was a case series, a cross-sectional effort, a cohort or a case-control study; where relevant, it will be stated if the study was retrospective or prospective
* Technological characteristics of the telehealth platform (e.g., ISDN- or IP-based, resolution level)
* Patient population (e.g., sample size, demographic characteristics)
* Setting (e.g., rural or urban)
* Originator of the consultation (e.g., family physician, nurse, community member)
* Comparison group(s) (e.g., face to face)
* Purpose of the consultation (e.g., acute, non-acute, education, diagnosis, therapeutic support, follow up)
* Outcomes measured and main findings (e.g., impact on health outcomes, process of care, resource use).

Health outcomeswere defined as an effect on an individual’s health status or a clinical consequence (e.g., increased compliance with treatment or reduced burden of illness). Rates of diagnostic concordance, only if reported with other health or non-health outcomes, were considered for this category. Process of careoutcomes described access to care, wait times, or time to completion for a clinical encounter. Outcomes on resource utilization included reports of cost-effectiveness data or impact on hospital admissions, visit frequency, or rate of referrals. User satisfaction was used to categorize feedback from a patient or provider on satisfaction, expectations, or acceptance of asynchronous telehealth.

### **Strategy for quality assessment**

The methodological quality of each study was assessed using the Jadad scale for randomized controlled trials (RCTs),4 and the Downs and Black checklist for observational studies and controlled clinical trials (CCT)5. The last question (question 27) on the Downs and Black checklist is designed to assess the study’s statistical power. Because the Downs and Black checklist was only used for qualitative studies and CCTs, we used a modified score with “0” or “1,” based on whether authors reported statistical power tests in the original article (score = 1) or not (score = 0). The modified scale allowed for a maximum possible total score of 28 for a given study.

The median study quality score was used to distinguish between low quality and high quality studies where no pre-specified score existed.6 In this review, randomized control trials were considered to be high quality if they received a Jadad score greater than 2 points or a score greater than 14 points using the Downs and Black checklist.

### **Data analysis**

The reports were categorized by medical specialty.

A general description was provided for the set of publications meeting the inclusion criteria with general characteristics and quality scores for the individual publications. Evidence tables were produced to summarize the information extracted from the publications.

Results were presented qualitatively. A meta-analysis was considered to be inappropriate because studies were deemed to display clinical heterogeneity. There were significant disparities among studies in clinical condition, acuity of health service delivery (acute, chronic), clinical setting, and technological intervention.

## Results

The literature search yielded 238 publications, of which 139 reports were excluded because they did not address issues related to clinical asynchronous telehealth. A total of 99 potentially eligible publications required the full-text version for further investigation. After review of the full-text version, 37 reports were excluded for various reasons (Table 1).

From the remaining 62 publications, ten were excluded because they did not address clinical domains traditionally associated with in-person care (Appendix 2). Six7-12 of these involved pathology (i.e., telepathology) while four13-16 addressed radiological applications (i.e., teleradiology).

A summary of the selection process appears in Figure 1.

### **Study Characteristics** (Appendix 3 and 4)

Fifty-two studies were included in this review with seven17-23 published before 2000.

The primary author was based in the US in 22 publications17, 19, 22-41 while 15 publications20, 21, 42-46, 47 , 48-54 originated from the UK. The remaining studies were distributed across various countries with Italy producing three55-57 and two58, 59 from The Netherlands. Canada was responsible for one publication.60

Study designs included three randomized control trials (RCTs)41, 47, 50 and seven surveys30, 40, 44-46, 54, 56 Thirty-six publications were designed as a case series, while six reports were characterized as cohort studies.

A funding source was not documented in 24 publications. No industry sources were reported, other than funding of equipment for study purposes.

Dermatology was the most represented clinical domain with 24 publications. Nine articles addressed mixed medical conditions,19, 23, 36, 39, 53, 57, 60, 26, 61 six musculoskeletal medicine,24, 33, 38, 42, 43, 55 four27, 28, 34, 35 paediatrics, and two29, 62 ophthalmology. Other clinical settings included plastic surgery and the neurological sciences.

#### Quality assessments

One of three RCTs was judged to be of high quality.50

Of the remaining 49 studies, 15 received high quality ratings.20, 24, 25, 28, 35, 40, 42, 45, 46, 52, 58, 62-65

### **Data analyses and synthesis**

#### Dermatology

Many publications in this group addressed more than one outcome. Health outcomes (mainly diagnostic accuracy), user satisfaction and resource use were the most commonly represented categories.

Health outcomes: Eleven publications evaluated the role of health outcomes. Ten of these reported on diagnostic concordance or diagnostic accuracy. Several publications reported high levels of diagnostic accuracy when using teledermatology. One study reported that diagnostic accuracy was obtained in 73% of cases for all skin lesions and 90% when evaluating skin cancer lesions.25 Other reports documented rates of diagnostic accuracy varying between 75% and 88%.17, 52, 63 Combining images from telehealth modalities with standard patient histories increased diagnostic accuracy to 90% and 82% (*P* <0.001) for two teledermatologists.63 There was a high level of agreement with the gold standard (face-to-face) of 0.91 (95% CI 0.82 to 1.00) for clinical teleconsultation and 0.94 (95% CI 0.88 to 1.00) for teledermatoscopy (*P* >0.05).65 Discrepancies were reported in the ability of asynchronous telehealth to contribute to the development of a management plan. In one study,66 an appropriate management plan was developed in 84% of the cases, but another study48 suggested that the use of asynchronous telehealth was successful in 55% of cases while 45% could not be properly assessed. Mallett reported that “advice only” was possible in 8% of cases.49

Process of care: Nine publications assessed process of care outcomes with most studies reporting a reduction in time to consultation. The average time between referral and clinical advice was reported to be 46 hours in one publication.66 Massone67 reported that of 133 requests analysed, 80 (60%) were answered within one day. The use of teledermatology resulted in a time to initial definitive intervention that was significantly shorter than that of usual care (median 41 days versus 127 days, *P* <0.0001), with 18.5% of patients in the teledermatology arm avoiding the need to visit a dermatology clinic.41 Klaz64 noted that the average wait times for asynchronous telehealth consultations were 50% less than those of face-to-face consultation. The time to perform a consultation was also affected by the use of asynchronous telehealth with the time to complete a telehealth consult one-third shorter on average than an in-person assessment.22 Three studies reported the ability to properly prioritize patients to address medical urgency.21, 52, 59 White21 reported that asynchronous telehealth, including the use of images resulted in more accurate triage in 50% of cases. Teledermatology also resulted in 14% of non-urgent referrals being upgraded to urgent while another 17% were deemed to need assessment when none was planned.52, 59

*Multiple clinical domains*

There were no data reported on health outcomes in this set of studies.

Process of care: Articles generally reported that less time was needed to process referrals. Most asynchronous telemedicine cases (67%) had a total turn-around time of less than 72 hours with an average turn around time for store-and-forward cases almost 40% faster than for real-time telehealth.19 Replies within one day of referral were provided in 70% to 87.5% of cases and within three days of referral in 100% of cases. 36, 53 Actual telemedicine consultations were completed within three days in 14 cases (52%) and within three weeks in 24 cases (89%). Vladymyrszki61 reported that the median interval between a request for teleconsultation and it being conducted was less than one day, with an acceptance of treatment results in 88% of cases.

#### Orthopaedics

Five publications in the area of musculoskeletal medicine, assessed trauma or injury.24, 38, 42, 43, 55 One33 focused on post-operative recovery after shoulder surgery.

Health outcomes*:* One study assessed the validity of asynchronous telemedicine, noting minimal diagnostic disagreement (5% intraobserver and 5.5% inter-observer differences) with face-to-face and similar treatment plans to deliver care.24 None of the differences identified were regarded as serious (e.g., limb- or life-threatening). Archbold42 reported that 17% of asynchronous consults changed the initial management plan. The authors reported that all images of the injury revealed that initial descriptions submitted by the referring physician were inaccurate with respect to the pathology.

Process of care: The one study assessing process of care documented that the average time spent by orthopaedic specialists was longer in videoconferencing [21 minutes, standard deviation (SD) 8] than in asynchronous teleconsultations (19 minutes, SD 8). However, a clinician’s confidence in the diagnosis was generally lower with asynchronous consultations.55

#### Paediatrics

All studies in this group reported health outcomes while three27, 34, 35 evaluated resource use.

Health outcomes*:* The use of asynchronous telehealth for paediatric care was associated with positive health outcomes. Two studies, with a combined sample size of 17 patients, assessed the effect of asynchronous telemedicine in paediatric asthma.28, 34 Inhaler technique scores and quality of life survey scores improved in the intervention group.28 The use of asynchronous telehealth was also thought to be helpful in modifying the diagnosis in up to 15% of cases.27 One study on acute illnesses noted a 63% reduction in absence from school due to illness with the use of telemedicine.35

#### Other conditions

Two studies focused on ocular conditions. Diagnostic agreement was reported in 12/15 cases that presented with strabismus.29 In screening for retinopathy, with the use of a digital ophthalmoscope, the detection rate for digital imaging (8.8%) was twice as high as that obtained with indirect ophthalmoscopy (4.4%).62 One study, which assessed the provision of non-surgical consultations to underserved communities, reported that the use of synchronous and asynchronous telemedicine resulted in enhanced communication with colleagues (86% and 80% respectively).56 Kokesh31 documented that the use of asynchronous telehealth reduced wait times of 4 to 15 months “significantly,” though specific data were not provided.

**Economic analysis**

Eleven publications in teledermatology reported outcomes pertaining to resource use. Two studies41, 47 quantified costs and reported their outcomes in two68,69 separate publications. Asynchronous telehealth was found to be less expensive than real-time teleconsultation but its clinical usefulness was limited.68 Whited69 noted that teledermatology was not associated with cost-savings but seemed to be cost-effective when the faster time to definitive treatment was taken into account. The use of asynchronous teledermatology also decreased the frequency of in-person visits or avoided them altogether. Eminovic58 reported that 58% of cases required less frequent in-person visits. The avoidance of an in-person visit ranged from 8% to 53%.21, 22, 48, 49, 52, 58, 59, 64 One publication reported that teledermatology resulted in the avoidance of 45% of in-person visits producing a 15% to 20% decline in workload.22

In mixed (i.e., multiple) clinical domains, two publications reported an approximately 15% to 23% reduction in patient transfers.53, 60 One Canadian study60 reported that of the 101 patients evaluated, eight emergency transfers were avoided, and 15 patients who would have required elective transfer were managed locally via telemedicine. No study in this group provided actual cost data. One study stated, “Cost savings have been substantial, not only direct costs but long distance telephone charges have been markedly reduced.”39

Similar findings were noted in neurological conditions where care was changed in 50% of the cases as a result of the specialist’s advice and one transfer of a patient out of the country was avoided.51 The use of teleradiology, in the context of neurosurgical evaluation, reduced the need to transfer a patient by 50%.18

Studies in orthopaedics reported that the transport of plain films by taxi was avoided in 10 referrals42 while in other settings patients avoided transfer or referral.38, 43 Finally, in otolaryngology, 79 of 91 patients saved transport costs producing a savings of US$307.57 per person.31 This study concluded that for every $1 spent on reimbursement for telehealth, $8 of travel cost could be avoided.

Three paediatric studies reported a decrease in health care use. Malone34 noted a drop in emergency room visits (3.85 ± −5.14, range 0 to 15 versus 0 visits, *P* <0.05) and admissions (1.57, SD 1.27, range 0 to 4 versus 0.286, SD 0.48, *P* <0.05), compared with the year before. McConnochie35 also reported fewer visits to the emergency room while Callahan27 reported avoidance of air evacuation in 12% of the population.

## User satisfaction

Patient or provider satisfaction was assessed in 11 teledermatology publications and in general was determined to be high. Ninety-three per cent of patients reported that they were happy with teleconsultation.54 Klaz64 noted an 89% patient satisfaction rate with higher results in rural compared with urban areas. Two studies45, 63 reported that 85% of patients said they would accept teledermatology in the future, with 18% feeling that the conventional asynchronous method was sufficient. In contrast, 38% to 40% agreed with the statement that they would prefer to discuss their skin problem with the dermatologist in person and preferred direct contact.45, 54 In addition, 40% said that they would feel that something important was missing if they did not see the dermatologist in person. When placed in the context of longer wait times, 76% preferred to be assessed by telemedicine rather than wait for an in-person consultation.45

Most dermatologists felt comfortable making a diagnosis and devising a treatment plan in those cases for which they had access to the image and the patient’s history.17 One early study noted that 81% of general practitioners anticipated problems with implementation while 15% said that expectations were high.44 This compares with a more recent publication documenting that 84% of providers had high expectations at the start of the study and 21% had similar expectations at the end.46 Furthermore, 21% were satisfied with teledermatology, while 47% were dissatisfied, and 32% unsure. The most common reasons cited for negative responses were complex process and increased workload.

Three studies26, 39, 60 assessing multiple clinical domains commented on patient and provider satisfaction. One study documented that patients were satisfied or very satisfied with the care received.26 Two others commented on positive acceptance and a general perception of asynchronous telehealth as being beneficial.39, 60

# DISCUSSION

Similar to other systematic reviews on telehealth, the original literature in general was judged to be of low quality.70-72 Most publications did not follow basic methodological principles or they described results from small samples, which are usually part of feasibility studies or pilot projects. Despite the poor quality of evidence, there were consistent trends across many studies.

Beyond diagnostic accuracy and concordance, most publications did not report meaningful data on health outcomes such as individual health status or other clinical parameters. The best evidence for improved health outcomes was found in the management of paediatric asthma. These studies reported positive effects on treatment compliance and a reduction in the need for acute intervention. This is consistent with previously reported evidence supporting the use of telemedicine in the management of chronic conditions.70

Several publications, mostly in teledermatology and some that assessed multiple clinical domains, reported a positive impact on process of care outcomes including a reduction in time to consultation, shorter wait times, and less time to perform a consultation. In some cases, the reduction in wait time was significant relative to face-to-face care, decreasing by almost 50%.64 Improved triage facilitated the prioritization of patients based on urgency, enhancing workflow logistics. It remains unclear whether triage leads to overall faster care or improved health outcomes. What remains unknown is whether these expectations could be met if asynchronous technology was to be expanded beyond small pilot projects and feasibility studies.

The results of this review are consistent with findings from previous efforts, which suggest that the methods to assess cost-effectiveness of telehealth are poor.71 Most evidence for cost savings is implied through indirect effects on a reduction in resource utilization. Cost savings in these situations are achieved through the avoidance of patient generated costs such as those associated with travel, lost time from work, or caregiver reimbursement. These costs, though not insignificant, are variable and correlated with travel distance. Studies seeking to prove cost-effectiveness in more urban areas may not prove to be compelling. Other studies reported a decreased frequency or avoidance of transfer of patients. This was most notable for the triage of surgical cases in orthopaedics and neurosurgery. In these situations, it could be possible to avoid the mobilization of health professionals (e.g., ambulance attendant, nurse, physician).

The quality of literature on patient satisfaction, as in other aspects of telehealth, was considered to be poor.73 Consistent with previous publications, however, satisfaction levels were generally above 80% for teledermatology although some studies reported a preference for in-person consultation.45, 54 The satisfaction ratings seemed to be influenced by wait times for obtaining traditional in-person care. Provider acceptance was mixed with consultants less averse to the use of teledermatology compared with primary care providers. The latter group perceived the complexity of the referral process and the increased workload as negative factors. In most of the other clinical domains, however, clinicians reported a positive acceptance of the use of asynchronous telehealth.

The scope of asynchronous telehealth was limited in this review. Specifically, the search strategy focused on the clinical applications of asynchronous telehealth but may not have identified all evaluations of remote home-based monitoring. The best evidence for improved health outcomes appears to originate from this latter body of literature. A review focusing on this area may generate more robust results to support the use of asynchronous telehealth. Additionally, the ten publications that were identified in pathology and radiology, were not included in this report. These clinical domains may add information with respect to the benefits of asynchronous telehealth. These publications were excluded to maintain consistency with other literature on asynchronous telehealth, which generally distinguishes between traditional face-to-face and non-face-to-face clinical domains.

Despite repeated calls for improved study designs, methodological quality and standardized outcome assessments, the overall quality of the telehealth literature remains poor. However, although the evidence is weak, there are trends that support the use of asynchronous telehealth as a supplement, rather than as a replacement, for other health services. Specifically, there is consistent evidence suggesting that asynchronous telehealth could lead to shorter wait times, fewer unnecessary referrals, high levels of patient and provider satisfaction, and equivalent (or even better) diagnostic accuracy when compared with face-to-face consultations.

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### **Table 1**. Excluded studies from asynchronous telehealth review

|  |  |
| --- | --- |
| **Publication** | **Reason for exclusion** |
| Burgess74 | Assessed concordance only |
| Hill75 | Assessed concordance only |
| Houston76 | Assessed concordance only |
| Jones77 | Assessed concordance only |
| Lattimore78 | Assessed concordance only |
| Minervini79 | Assessed concordance only |
| Piccolo80 | Assessed concordance only |
| Szot81 | Assessed concordance only |
| Sclafani82 | Assessed concordance only |
| Duerinckx83 | Did not assess asynchronous technology |
| Kanzaki84 | Did not assess asynchronous technology |
| Sibson85 | Duplicate study population |
| Demiris86 | No original data reported |
| Leong87 | No original data reported |
| Oakley88 | No original data reported |
| Umefjord89 | No original data reported |
| Whitten90 | No original data reported |
| Blum91 | Publication did not report any outcome data |
| Chang92 | Publication did not report any outcome data |
| Dunn93 | Publication did not report any outcome data |
| Gilbert94 | Publication did not report any outcome data |
| Krumm95 | Publication did not report any outcome data |
| Person96 | Publication did not report any outcome data |
| Sanchez97 | Publication did not report any outcome data |
| Sood98 | Publication did not report any outcome data |
| Sussmann99 | Publication did not report any outcome data |
| Munir100 | Publication of case report |
| Weinstock101 | Publication of case report |
| Loane68 | Subset data from Loane 47 |
| Whited69 | Subset data from Whited41 |
| Whited102 | Subset data from Whited41 |
| Currell103 | Systematic review |
| Whited104 | Systematic review |
| Williams73 | Systematic review |
| Desai105 | Unable to retrieve full-text through multiple sources |
| Kuo106 | Unable to retrieve full-text through multiple sources |
| Mallett107 | Unable to retrieve full-text through multiple sources |
| Pavlicek108 | Unable to retrieve full-text through multiple sources |

**Figure 1. QUOROM Flowchart**

*Potentially relevant studies identified through electronic search*

*n = 238*

.

(n=863)

*Studies requiring more detailed evaluation*

*n = 153*

*Studies requiring full-text retrieval n = 99*

*Studies included in systematic review*

n = 52

*Studies not relevant to systematic review n = 85*

*Studies not relevant to systematic review*

*n = 54*

* 33 not relevant to systematic review
* 19 concordance data only
* 2 systematic reviews

*Studies not relevant to review from full-text review*

*n = 37*

* 5 no original data
* 9 concordance data only
* 8 no outcome data
* 2 not asynchronous telehealth
* 2 case reports
* 4 unable to retrieve
* 4 duplicate studies
* 3 systematic reviews

*Studies pertaining to pathology or radiology n = 10*

## Appendix 1: Medline search strategy for Asynchronous/Store-and-Forward

|  |  |  |
| --- | --- | --- |
| Ovid MEDLINE(R) | | |
| # | Search History | Results |
| 1 | exp Primary Health Care/ | 47070 |
| 2 | exp Physicians, Family/ | 11027 |
| 3 | exp Family Practice/ | 49769 |
| 4 | exp Community medicine/ | 1655 |
| 5 | exp Group practice/ | 21139 |
| 6 | exp Physician's Practice Patterns/ | 22015 |
| 7 | exp Physicians' Offices/ | 1153 |
| 8 | exp Practice management, medical/ | 6650 |
| 9 | exp Regional medical programs/ | 3134 |
| 10 | exp ambulatory care/ | 37589 |
| 11 | exp outpatient clinics/ | 32264 |
| 12 | exp homes for the aged/ | 8057 |
| 13 | house calls/ | 1574 |
| 14 | Private practice/ | 5815 |
| 15 | Rural Health Services/ | 5036 |
| 16 | Hospitals, Rural/ | 3197 |
| 17 | Rural Health/ | 17048 |
| 18 | Rural Population/ | 26192 |
| 19 | northwest territories/ or nunavut/ or yukon territory/ | 293 |
| 20 | Arctic Regions/ | 2493 |
| **21** | **northern territory/** | **595** |
| 22 | Indians, north american/ or inuits/ | 10304 |
| **23** | **Health services, indigenous/** | **1207** |
| 24 | outpatient:.mp. | 75951 |
| 25 | out-patient:.mp. | 9626 |
| 26 | (free-standing adj2 clinic?).mp. | 57 |
| 27 | (free-standing adj2 facilit:).mp. | 39 |
| 28 | ambulatory care facilities/ or community health centers/ or substance abuse treatment centers/ or community mental health centers/ or child guidance clinics/ or maternal-child health centers/ or outpatient clinics, hospital/ or pain clinics/ or surgicenters/ | 32264 |
| **29** | **general practitioner:.mp.** | **23064** |
| **30** | **exp medicine/** | **505183** |
| 31 | or/1-30 | 767111 |
| 32 | (online or on-line).tw. | 20338 |
| 33 | (remote: adj2 consult:).tw. | 148 |
| 34 | (web page: or webpage:).tw. | 620 |
| 35 | (web-site: or website:).tw. | 5119 |
| 36 | Answering Services/ | 15 |
| 37 | cellular phone/ | 759 |
| 38 | comput:.tw. | 290233 |
| 39 | cyber:.tw. | 1549 |
| 40 | digital:.tw. | 49073 |
| 41 | discussion list:.tw. | 68 |
| 42 | e-bulletin board:.tw. | 0 |
| 43 | electron: bulletin board:.tw. | 52 |
| 44 | electron: discuss: board:.tw. | 5 |
| 45 | electron: mail:.tw. | 498 |
| 46 | electronic mail/ | 681 |
| 47 | electronic:.tw. | 36300 |
| 48 | e-mail:.tw. | 1821 |
| 49 | email:.tw. | 502 |
| 50 | exp computer communication networks/ | 32709 |
| 51 | exp online systems/ | 8319 |
| 52 | exp computer-assisted instruction/ | 5693 |
| 53 | exp diagnosis, computer-assisted/ | 24386 |
| 54 | exp therapy, computer-assisted/ | 14543 |
| 55 | exp computers, handheld/ | 767 |
| 56 | exp decision making, computer-assisted/ | 39205 |
| 57 | exp electronics, medical/ | 5624 |
| 58 | exp internet/ | 22134 |
| 59 | exp microcomputers/ | 14067 |
| 60 | exp telecommunications/ | 31758 |
| 61 | exp user-computer interface/ | 12397 |
| 62 | (handheld adj2 computer:).tw. | 219 |
| 63 | (hand held adj2 computer:).tw. | 201 |
| 64 | information highway:.tw. | 72 |
| 65 | information superhighway:.tw. | 128 |
| 66 | information super highway:.tw. | 11 |
| 67 | Instant messag:.tw. | 20 |
| 68 | text messag:.tw. | 47 |
| 69 | internet:.tw. | 11655 |
| 70 | (irc and (internet: or online or on-line or chat: or relay)).tw. | 11 |
| 71 | list serv:.tw. | 44 |
| 72 | Listserv:.tw. | 120 |
| 73 | mail: list:.tw. | 326 |
| 74 | messaging:.tw. | 217 |
| 75 | Microscopy, Video/ | 3465 |
| 76 | modems/ | 220 |
| 77 | Mobile phone:.tw. | 563 |
| 78 | mobilephone:.tw. | 0 |
| 79 | Mobile telephone:.tw. | 152 |
| 80 | Mobile telecom:.tw. | 41 |
| 81 | Mobile communic:.tw. | 150 |
| 82 | newsgroup:.tw. | 105 |
| 83 | ((pda or pdas) and (comput: or internet: or wireless:)).tw. | 223 |
| 84 | personal digital assistant:.tw. | 375 |
| 85 | Pocket pc:.tw. | 21 |
| 86 | pocketpc:.tw. | 5 |
| 87 | Radar/ | 379 |
| 88 | Radio/ | 1658 |
| 89 | Remote Consultation/ | 2239 |
| 90 | Satellite Communications/ | 472 |
| 91 | short messag:.tw. | 37 |
| 92 | (sms and (internet: or online or on-line or chat: or relay: or wireless:)).tw. | 19 |
| 93 | exp Software/ | 59775 |
| 94 | tele:.tw. | 61774 |
| 95 | exp Telecommunications/ | 31758 |
| 96 | teleconfer:.tw. | 377 |
| 97 | tele-confer:.tw. | 8 |
| 98 | teleconsult:.tw. | 451 |
| 99 | tele-consult:.tw. | 15 |
| 100 | Telefacsimile/ | 177 |
| 101 | (tele-home: or telehome:).tw. | 57 |
| 102 | telemed:.tw. | 3494 |
| 103 | tele-med:.tw. | 37 |
| 104 | Telemedicine/ | 5442 |
| 105 | Telepathology/ | 454 |
| 106 | exp Telephone/ | 7499 |
| 107 | usenet:.tw. | 20 |
| 108 | videoconfer:.tw. | 616 |
| 109 | video-confer:.tw. | 201 |
| 110 | Videoconferencing/ | 123 |
| 111 | videophone:.tw. | 53 |
| 112 | virtual.tw. | 10512 |
| 113 | web based:.tw. | 3484 |
| 114 | webbased:.tw. | 4 |
| 115 | world wide web:.tw. | 2208 |
| 116 | www.tw. | 1078 |
| 117 | telestroke.mp. | 12 |
| 118 | tele-stroke:.mp. | 0 |
| 119 | teleneurology.mp. | 13 |
| 120 | tele-neurology.mp. | 2 |
| 121 | telehealth:.mp. | 590 |
| 122 | tele-health:.mp. | 14 |
| 123 | telerehab:.mp. | 58 |
| 124 | tele-rehab:.mp. | 7 |
| 125 | teleservic:.mp. | 10 |
| 126 | tele-servic:.mp. | 0 |
| 127 | or/32-126 | 539384 |
| 128 | 31 and 127 | 44778 |
| 129 | asynchrono:.mp. | 4852 |
| **130** | **unsynchron:.mp.** | **257** |
| 131 | "store and forward:".mp. | 181 |
| **132** | **"store forward:".mp.** | **5** |
| 133 | or/129-132 | 5284 |
| 134 | 128 and 133 | 264 |
| 135 | limit 134 to english language | 251 |

## Appendix 2: General characteristics of studies for radiology and pathology (Asynchronous telehealth)

| **Author** | **Year of publication** | **Source of publication** | **Country** | **Funding source** | **Type of study** | **Quality score**  **(DB)** |
| --- | --- | --- | --- | --- | --- | --- |
| Desai 7 | 2004 | Indian Journal of Pathology and Microbiology | India | Not reported | Case series | 16 |
| Dunn 9 | 1997 | Telemedicine Journal | USA | Not reported | Case series | 12 |
| Dunn 8 | 1999 | Telemedicine Journal | USA | Hybrid open system technology program of Department of veterans affair | Case series | 17 |
| Gomez 13 | 2001 | Computer Methods & Programs in Biomedicine | Spain | EU Advanced Communication Technologies and Services | Case series | 4 |
| Hussain 14 | 1999 | Journal of Telemedicine & Telecare | UK | Not reported-- (British Telecom for support) | Case series | 10 |
| Johnson 15 | 1998 | Telemedicine Journal | Canada | Not reported | Cohort (prospective) | 16 |
| Lanschuetzer 10 | 2004 | Journal of Telemedicine & Telecare | Austria | Not reported | Case series | 10 |
| Lewis 16 | 2005 | Journal of Telemedicine and Telecare | Australia | Not reported | Survey | 12 |
| Marcelo 11 | 2000 | Archives of pathology & laboratory medicine | USA | Not reported | RCT | 5(JS) |
| Settakorn 12 | 2002 | Telemedicine Journal & E-Health | Thailand | Nara Medical University Scholarship | Cohort (prospective) | 12 |

RCT=Randomized control trial

JS=Jadad scale

DB=Downs and Black checklist

## Appendix 3: General characteristics for studies included in review (Asynchronous telehealth)

| **Author** | Year of publication | Source of publication | Country | **Funding source** | **Type of study** | **Quality score**  **(DB)** |
| --- | --- | --- | --- | --- | --- | --- |
| Abboud 24 | 2005 | Clinical Orthopaedics & Related Research | USA | Not reported | Case series | 19 |
| Archbold 42 | 2005 | Injury | UK-Ireland | Vodaphone | Case series | 16 |
| Baba 63 | 2005 | Journal of Telemedicine & Telecare | Turkey | Not reported | Case series | 18 |
| Barnard 25 | 2000 | Telemedicine Journal & E-Health | USA | Not reported | Case series | 15 |
| Baruffaldi 55 | 2002 | Journal of Telemedicine & Telecare | Italy | Not reported | Case series | 10 |
| Beach 43 | 2000 | Journal of Telemedicine & Telecare | UK | NHS Executive, (telemedicine equipment loaned by ADV Communications and software by Telemarque Ltd | Case series | 6 |
| Brandling-Bennett 26 | 2005 | Telemedicine Journal & E-Health | USA | Not reported | Case series (retrospective) | 13 |
| Callahan 27 | 2005 | Archives of Pediatrics & Adolescent Medicine | USA | US Army Medical Research Acquisition | Case series | 12 |
| Chan 28 | 2003 | American journal of Health-Syst Pharm | USA | US Army research acquisition activity | Case series | 17 |
| Chen 62 | 2004 | Journal of Telemedicine & Telecare | Taiwan | Not reported | Case series | 14 |
| Collins 46 | 2004 | Journal of Telemedicine & Telecare | UK | NHS R&D Health Technology Assessment Programme | Survey | 15 |
| Collins 45 | 2004 | Journal of Telemedicine & Telecare | UK | UK NHS R&D Health Technology Assessment Programme | Survey | 17 |
| Collins 44 | 2000 | Journal of Telemedicine & Telecare | UK | NHS R&D Health Technology Assessment Programme | Survey | 12 |
| Eminovic58 | 2003 | Journal of Telemedicine & Telecare | The Netherlands | KYOS Research foundation (non-profit organization based at the dermatology department of the AMC) | Cohort (prospective) | 19 |
| Fortin 60 | 2003 | Journal of Telemedicine & Telecare | Canada | Health Canada Transition Fund | Case series and semi-structured interview | 13 |
| Gomez 23 | 1996 | Telemedicine Journal | USA | Not reported | Cohort (retrospective) | 10 |
| Heautot18 | 1999 | Medical Informatics & the Internet in Medicine | France | Ministry of Industry, the Region of Brittany | Case series | 8 |
| Helveston 29 | 2001 | Journal of American Association for Pediatric Ophthalmology & Strabismus | USA | Equipment sponsored by Education and Research Foundation for Children’s Eyes, Indianapolis, Indiana, and Clody and Riley’s “One-Eyed Golf.” | Case series (before and after) | 8 |
| Hersh 30 | 2002 | AMIA Annual Symposium Proceedings | USA | Eugene Garfield Foundation, OHSU Hospital, OHSU Medical Group, and Asante Health System | Survey | 12 |
| Hockey 66 | 2004 | Journal of Telemedicine & Telecare | Australia | Commonwealth Department of Health and Ageing (Medical Specialist Outreach Assistance Programme) | Case series | 11 |
| Klaz 64 | 2005 | Israel Medical Association Journal | Israel | Israel Defense Forces Medical Corps. | Multicenter uncontrolled cohort (prospective) | 18 |
| Knol 59 | 2006 | Journal of Telemedicine and Telecare | The Netherlands | Not reported | Cohort (prospective) | 13 |
| Kokesh 31 | 2004 | International Journal of Circumpolar Health | USA | Not reported | Case series (descriptive) | 2 |
| Krupinski 19 | 1999 | Telemedicine Journal | USA | US Department of Agriculture Rural Utilities Service Distance Learning, U.S Department of Commerce, National telecommunications and Information Administration, Office of Rural Health Policy, Department of Health and Human Services Rural | Case series | 12 |
| Krupinski32 | 2004 | Journal of Telemedicine & Telecare | USA | Not reported | Cohort (retrospective) | 12 |
| Larcher 56 | 2003 | Medical Informatics & the Internet in Medicine | Italy | Public Health Institute of the Government of Italy | Survey | 13 |
| Lau 33 | 2002 | IEEE Transactions on Biomedical Engineering | USA | Not reported | Case series (descriptive) | 9 |
| Loane 47 | 2000 | Journal of Telemedicine & Telecare | UK | NHS R&D | RCT | 2(JS) |
| Mahendran48 | 2005 | Clinical &Experimental Dermatology | UK | Not reported | Case series | 13 |
| Malacarne57 | 2004 | Telemedicine Journal & E-Health | Italy | Not reported | Case series | 11 |
| Mallett49 | 2003 | Clinical & Experimental Dermatology Clinical and experimental dermatology | UK | Not reported | Case series | 6 |
| Malone34 | 2004 | Telemedicine Journal & E-Health | USA | Pacific Telehealth and Technology Hui and Medical Health care facilities | Case series | 12 |
| Mandall 50 | 2005 | British Dental Journal | UK | Not clearly stated | RCT | 3(JS) |
| Massone67 | 2006 | Journal of Telemedicine and Telecare | Austria | Not reported | Case series (descriptive) | 7 |
| McConnochie 35 | 2005 | Pediatrics | USA | US Department of Commerce Technology Opportunities Program, Robert Wood Johnson Foundation Local Initiative Funding | Case series (before and after) | 15 |
| Moreno-Ramirez 65 | 2006 | Clinical & Experimental Dermatology | Spain | ‘Instituto Carlos III’ of the Spanish Health Ministry | Case series | 14 |
| Mukundan36 | 2003 | Acad Radiol Academic Radiology | USA | Swifen Charitable Trust, Cantebury, England Not reported | Case series | 11 |
| Pak 22 | 1999 | Studies in Health Technology and Information | USA | Walter Reed Army Medical Cente | Cohort (retrospective) | 10 |
| Pap37 | 2002 | Plastic & Reconstructive Surgery | USA | Not reported | Case series | 11 |
| Patterson 51 | 2001 | Journal of Telemedicine & Telecare | UK | Not reported | Case series | 12 |
| Person 38 | 2003 | Telemedicine Journal & E-Health | USA | THE PACIFIC ISLAND HEALTH CARE PROJECT (PIHCP) | Case reports | 6 |
| Person39 | 2000 | Pacific Health Dialog | USA | Not reported | Case series | 6 |
| Rodas 109 | 2005 | Journal of Telemedicine & Telecare | Ecuador | NASA and Instituto de Investigacionesde la Universidad de Cuenca (IDIUC). | Case series | 11 |
| Sibson 20 | 1999 | Medical Informatics & the Internet in Medicine | UK | NHS Research and Development Waiting List Taskforce fund. | Case series and survey | 15 |
| Taylor 52 | 2001 | British Journal of Dermatology | UK | Not reported | Case series | 17 |
| Vassallo 53 | 2001 | Journal of Telemedicine & Telecare | UK | The Swinfen Charitable Trust (SCT) | Case series | 12 |
| Vladzymyrskyy 61 | 2005 | Journal of Telemedicine & Telecare | Ukraine | Not reported | Case series | 8 |
| Weinstock 40 | 2002 | Journal of the American Academy of Dermatology | USA | Cooperative Studies Program, Office of Research and Development, Department of Veterans Affairs | Survey | 14 |
| White21 | 1999 | Journal of Telemedicine & Telecare | UK | Not reported | Case series | 7 |
| Whited41 | 2002 | Telemedicine Journal and e-Health | USA | VA Health Services Research and Development Service. | RCT | 2(JS) |
| Williams 54 | 2001 | Journal of Telemedicine & Telecare | UK | Not reported | Survey | 10 |
| Zelickson 17 | 1997 | Archives of Dermatology | USA | Not reported | Case series | 13 |

DB=Downs and Black

JS=Jadad Scale

**Appendix 4:** Components and outcomes of studies included in review (Asynchronous telehealth)

| **Publication** | **Sample** | Intervention | **Clinical**  **Domain** | **Level of care** | **Outcome category** | | | | **Results** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| H | P | R | S |
| Abboud  200524 | 100 patients age range 8–79 years with disorders of upper extremity | Use of electronic history and digital image capture of radiological films and affected extremity with consumer quality camera and storage on PC | Orthopaedic | Diagnostic | H |  |  |  | 5.0% intra-observer differences and 5.5% inter-observer in diagnoses or treatment when comparing the face-to-face and electronic evaluations (none life/limb threatening).  Established intra-observer agreement of diagnosis and treatment plan (kappa=0.92 and 0.90, respectively) and inter-observer agreement of diagnosis and treatment plan (kappa=0.86 and 0.90, respectively) |
| Archbold  H=Health outcomes  P=Process of care  R=Resource utilization  S=Patient and provider satisfaction  200542 | 46 consecutive trauma consultations age range 4 to 90 years | Multi-media cell phone to capture images (mobile platform) including plain films and wound | Orthopaedic | Diagnostic | H |  | R | S | 8 of 46 consults felt to have changed the initial management and 10 referrals avoided forwarding plain films by taxi (cost savings), patient care improved in 34 out of the 46 cases (trauma surgeon) and 36 out of 46 cases (emergency physician). Ease of use acceptable 70% of the time. |
| Baba  200563  H=Health outcomes P=Process of care  R=Resource utilization S=Patient and provider satisfaction | 242 skin lesions on 228 patients age range 2-82 | PC based Web camera videoconferencing compared with electronic transfer of history and images obtained with digital camera | Dermatology | Diagnostic | H |  |  | S | Conventional SF method diagnostic accuracy of 2 teledermatologist was 81% and 75% but with combined method, the corresponding values were 90% and 82% (P<0.001 for both).  No significant difference in inter-observer agreement  Use of Web camera videoconferencing improved patient satisfaction with teledermatology.  85% of subjects would accept teledermatology in the future, of which, 82% thought that teleconsultation should include videoconferencing with Web cameras. |
| Barnard  200025 | 8 teledermatologists evaluated 50 cases submitted by other dermatologists with various skin conditions | Digital images of lesions taken with camera followed by brief electronic history | Dermatology | Diagnostic | H |  |  |  | Diagnostic accuracy for skin cancers was 88% versus 90% (range, 75–100%) for the in person and teleconsultants, respectively. For all confirmed cases the accuracy was 84% (in-person) compared to 73% (range, 65–88%). Teleconsultants changed their primary diagnosis in 11% of cases (range, 2–22%). Biopsy rates were not significantly different between teleconsultants (45%) and in-person dermatologists (40%). |
| Baruffaldi  200255 | 65 teleconsultations for second opinion on work-related injuries | Real-time VC (PC with document camera) or asynchronous with transfer of files across ISDN | Orthopaedic | Diagnostic |  | P |  |  | Average time spent was slightly longer in videoconferences (21 min, SD 8) than in asynchronous teleconsultations (19 min, SD 8). The clinicians’ confidence in diagnosis was lower in asynchronous consultations. Clinical complexity of the case and the organizational requirements were declared to be the main factors affecting the choice of consulting procedure. Asynchronous method was preferred in the majority of cases although some concerns about the diagnostic quality of the information transmitted. |
| Beach 200043 | 71 patients entering minor injury units | Low cost VC and asynchronous telemedicine transmitted over ISDN (no detail data provided) | Orthopaedic | Diagnostic |  |  | R |  | Data obtained in some cases avoided transfer or referral. Some changes in diagnosis and treatment for remote physician (no detail data provided) |
| Brandling-Bennett 200525 | 264 general clinic visits on 214 patients (age range 3 months to 80 years) in rural Cambodia. | Electronic history and digital images sent by email via satellite connection | Multiple | Diagnostic |  |  |  | S | All patients surveyed either “very satisfied” (46%) or “satisfied” (54%) with their care, and most patients were willing to pay for a visit, with a median amount of USD 0.63. |
| Callahan  200527 | 267 paediatric consultations from 16 different sites mean age 5+/-5 years | Web-based, store and forward, asynchronous, provider-provider teleconsultation with image capture device (digital camera, scanner, and video camera) | Paediatrics | Diagnostic | H | P | R |  | Mean ± SD response time by a consultant was 32 ± 14 hours. Initial diagnosis was changed or modified in 15% (39/267) of cases, the diagnostic plan was changed or modified in 21% (57/267), and the treatment plan was changed or modified in 24% (64/267) (P .01 for all). Routine air evacuations were avoided in 32 cases (12%). |
| Chan  2003 28 | 10 children (age range 6-17 years) with asthma submitting 321 videos of inhaler use and 309 peak flow meter videos undergoing virtual versus office based education | Home-based computer and video camera with Internet access | Paediatrics (asthma) | Therapeutic | H |  |  | S | Inhaler technique scores improved significantly (87% in periodd1) compared with period2 (94%). Less controller medication period 1, mean+/-SD (0.8+/-0.6), compared with 0.5+/-0.3. Peak flow values increased significantly. Overall, no change in quality of life but caregivers in virtual-education group reported increase in patients’ quality-of-life survey scores. Emergency department visits and hospital admissions were avoided. High rate of satisfaction with home telemonitoring |
| Chen  200462 | 113 patients (mean age 53 years) screening for ocular disorders in Tungyin, China | Digital ophthalmoscopy with image capture and transmission over ADSL | Ophthalmology | Diagnostic (screening) | H |  |  |  | Screening for retinopathy, the detection rate for digital imaging (8.8%) was two times higher than indirect ophthalmoscopy (4.4%). Community-based screening for four categories of eye disease successfully demonstrated. |
| Collins  2004 45 | 148 responses from 208 dermatology patients enrolled in RCT comparing traditional in-person care to teleconsultation | Asynchronous telemedicine (not specified) | Dermatology | Diagnostic |  |  |  | S | No statistical difference in satisfaction of care between 2 groups. 85% of teleconsultation group happy to use this system, 38% *prefer* to discuss their skin problem with dermatologist in person. 40% feel that something important was missing if they did not see the dermatologist in person. 76% would rather have their skin problem managed via telemedicine than have to wait. |
| Collins  200044 | 26 responses from a total of 35 GPs who agreed to participate in RCT | Asynchronous telemedicine (not specified) | Dermatology | Diagnostic |  |  |  | S | (81%, n=21; 95% CI 55–91%) anticipated problems with implementing the system. 15%(n=4; 95%CI 5–36%) respondents said their expectations of teledermatology were high. One in four respondents (27%, n=7; 95% CI 9–45%) felt confident or very confident about teledermatology diagnosis and management of care |
| Collins 2004 46 | 36/42 GPs enrolled in an RCT responded to a before and after questionnaire | Asynchronous telemedicine (not specified) | Dermatology | Diagnostic |  |  |  | S | 86% enthusiastic about teledermatology in contrast to 21% at end of study who felt all expectations had been met; 21% satisfied, 47% dissatisfied and 32% unsure; 31% confident in diagnosis and management, 28% unconfident and 41% unsure; high expectations pre-trial were more likely to be satisfied (Kendall’s tau-b=0.51, p=0.023); 12/26 felt positive about improved access; 11/33 felt referral process complex while 18/33 reported increased workload |
| Eminovic  200358 | 96 of 105 patients recruited (age range 4 months to 72 years) various skin lesions | Submission of electronic form and 4 digital images taken by patient | Dermatology | Diagnostic | H |  | R |  | 71% of cases further investigation proposed. 58% of cases needed (less frequent) in person consultation. 23% of patients no kind of hospital visit required. |
| Fortin  200360 | 118 transmissions involving 101 patients in Quebec various clinical domains | Store and forward imaging along with videoconferencing for other areas | Multiple | Diagnostic (19 patients received follow-up) | H |  | R | S | 8 emergency transfers avoided and 15 patients requiring elective transfer were managed locally. 3 unanticipated transfers carried out 13/15 patients satisfied while 25 health professionals interviewed and ‘majority’ perceived as beneficial |
| Gomez 1996 23 | 240 consults from 12 remote telemedicine sites across multiple clinical domains | Various digital image capture devices and transmission via satellite or commercial telephone lines | Multiple | Diagnostic |  | P |  |  | Most consults were routine (88%); 94% of consults were completed within the predefined telemedicine response criteria (24 hours for routine consults and 3 hours for emergencies). |
| Heautot  1999 18 | Patients presenting for emergency neurosurgical consults at distant hospital. 3 phases (I)-11 patients (no asynchronous), (II)-51cases (image transfer ISDN) and (III)-unknown | Proprietary software and DICOM to submit radiological images over ISDN/ATM | Neurosurgery | Diagnostic | H |  | R | S | Phase I-10/11 patients transferred 4 could have been avoided with images, Phase II 34/48 (71%) actual patient transfers with 8/48 transfers avoided, Phase III-62% transferred with image helpful in 50% of cases Up to 50 % unnecessary patient transfers avoided. non-urgent advice requests increased from 0 to 21 %. ATM network, the service gave satisfaction to all the physicians. |
| Helveston  200129 | Total of 50 patients with strabismus in various countries with 30 in Cuba | Digital image with PC storage on disk and transmission as attachment to email | Ophthalmology | Diagnostic |  |  | R |  | The transmission of text and images by e-mail was trouble-free, and communication in English was effective. The store-and-forward technique is a relatively simple, inexpensive, and versatile method of telemedicine. |
| Hersh  200230 | 31 clinicians in Oregon given access to a system to pose clinical questions | Web-based asynchronous application | Non-specific | Support (physician) |  |  |  | S | Clinicians displayed modest but enthusiastic use |
| Hockey  200466 | 15 GPs in Australia submitting 63 email consultation requests where no dermatologist access was available locally | Submission via email of electronic copy of history and digital image using consumer based camera | Dermatology | Diagnostic | H | P |  |  | Majority (53/63) of cases management plan developed based on email; 10 cases (16%) additional images or biopsy results requested (image quality inadequate) Average time between receiving referral and clinical advice being provided was 46 hours. GPs made more referrals the longer they stayed in study. |
| Klaz  200564 | 18 physicians in military units recruiting 435 patients (age range 18-39 years) from rural and urban centres with non-pigmented skin lesions. No comparison group. | Digital images uploaded from camera and sent along with electronic questionnaire via email | Dermatology | Diagnostic |  | P | R | S | Tele-diagnosis possible for 95% of 435. 22% of referrals required face-to-face consultation. Satisfaction high/very high among 89% patients in rural and urban clinics-significantly higher in rural units. Average wait time 50% less than face-to-face appointment. 87% PCPs were satisfied with the quality of the service and its contribution to their knowledge. Rural physicians rated level of service and overall satisfaction higher. |
| Knol  2006 59 | 505 consultations in 503 patients (age range 0-96 years) with skin lesions. Face-to-face comparison only for those requiring follow-up. | Electronic form and digital image transmission by email | Dermatology | Diagnostic | H | P | R |  | No difference between initial diagnosis and face-to-face in those requiring further follow-up. 163 patients were not referred because of teledermatology--a reduction of 53% (163/306); 17% of cases required traditional consultation when none was intended by GP |
| Kokesh  2004 31 | 91 patients provided store and forward services from rural communities with ear, nose and throat conditions | Video-otoscopy, digital surgical microscopy and other digital image capture devices for otolaryngology (details unspecified) | Otolaryngology | Diagnostic and Therapeutic |  | P | R |  | Analysis of the first 91 store-and-forward cases reimbursed by Medicaid revealed significant. Of 91 cases, 79 saved transport for the patient and escort at an average cost of  $307.57/person round-trip. For every $1 spent on reimbursement for telemedicine, almost $8 of travel cost was avoided. Wait times from 4-15months were reduced “significantly” |
| Krupinski  200432 | Comparison of 50 teledermatology patients to convenience sample of 50 assessed face to face for skin lesions | Digital image captured with camera and uploaded to proprietary software | Dermatology | Diagnostic |  |  | R |  | In-person group had fewer records about actions taken as a result of the consultation (e.g. performed a biopsy, prescribed a medication)-- 12% of the in-person records compared with 43% in teledermatology (z = 3.14, P<0.01). Both groups had similar follow-up rate with 8% vs. 10% (z=.094, p>0.05). |
| Krupinski  199919 | Unknown sample size. Based on review of program workload of 35 cases/month across 39 subspecialties | Multiple types of data/image capture and transfer to proprietary software via ATM | Multiple | Diagnostic |  | P |  |  | Majority of store-and-forward cases (67%) have a total turn-around time of <72 hours (mean 93.01h, SD142.43) compared with real-time cases (72%) with a total turnaround  time of .>72 hours. (mean=242.71h, SD271.63). SS: (t=8.051, df=498, p=0.0001). Main difference occurred in time from notification of consultant until consultation (RT-mean=175.05h vs. SF-36.62h) SS: (t=8.52, df=498, p=0.0001) |
| Larcher  200356 | Two questionnaires with responses of 33/35 and 22/38 physicians before and after performing 98 asynchronous teleconsultations with cancer patients | Web-based telehealth (no details provided) | Oncology | Diagnostic  /Therapeutic  /Support |  |  |  | S | Both modalities of teleconsultation useful in enhancing communication with colleagues (86% synchronous, 80% asynchronous). Major difficulties encountered were in the introduction of the system into the daily routine. user satisfaction:78% of sessions set goal was reached |
| Lau  200233 | 6 patients (average age 59 years) followed post-operatively after shoulder surgery | Web-based messaging system to send multimedia information and implement web-forms | Orthopaedic | Rehabilitative/  Follow-up (post-operatively) |  |  |  | S | User satisfaction between neutral and satisfied with overall mean rating 3.4 out of 5 (SD=0.85) |
| Loane  200047 | 204 patients (age range 4 months to 89 years) randomized into 2 groups of 102 patients each with various skin lesions | Real-time teledermatology (VC across ISDN) compared with still images from instant camera sent by post and face to face intervention | Dermatology | Diagnostic | H |  | R |  | 46% real-time teledermatology required at least one other hospital appointment compared with 45% of conventional outpatients and 69% of store-and-forward. Store-and-forward consultation was less expensive (€22.11 vs. €61.03)but clinical usefulness was limited. With sensitivity analysis real-time teledermatology as economical as conventional care when less artificial assumptions applied. |
| Mahendran  200548 | 163 patients presenting with one dermatological lesion compared with FTF | Electronic history and image capture with digital camera transmitted via email | Dermatology | Diagnostic | H |  | R |  | Management plan appropriate in 55% of consultants teledermatology cases (22% could have avoided face-to-face and 33% sent directly to minor surgery). 45% could not be managed by SF |
| Malacarne  200457 | 25 consecutive patients across 9 different specialty areas transmitted between Africa and Italy | Multiple types of data capture (patient history, ECG, radiology etc.) with transmission over ISDN | Multiple | Diagnostic |  |  | R |  | In 60% of cases, just one consultation was sufficient. Choosing the right specialist was the most critical phase of the operation. |
| Mallett  200349 | 727 images on 325 referrals (age range 4 months-94 years) with variety of skin lesions. Face-to-face comparison. | Digital image capture with camera and transmission via email over ISDN | Dermatology | Diagnostic | H |  | R |  | 95% concordance with teledermatology. An ‘advice only’ service was requested and given for only 26 patients (8%) while 256 patients required outpatient visit. (i.e. majority of patients still need to be seen in the outpatient clinic). Teledermatology unlikely to have significant impact on patient workload or solve waiting list problems |
| Malone  200434  H=Health outcomes  P=Process of care  R=Resource utilization  S=Patient and provider satisfaction | 7 patients (mean age 11.9 +/-3.7 years) with asthma | Web-based asthma pathway with MPEG video and spirometry | Paediatrics (asthma) | Therapeutic  Support | H |  | R |  | Fewer ED visits for asthma (3.85+/-5.14, range 0–15 vs. 0 visits, p<0.05) ; Fewer unscheduled acute clinic visits (1.57+/-1.27, range 0–4 vs. 0.286+/-0.48, p<0.05) in study year versus preceding year. 2 hospitalizations in year prior to and no patients hospitalized during the study; provider use of asthma action plan increased from 24% to 73% (p<0.01) and provision of asthma education increased from 18% to 73%, (p<0.01). Providers not more likely to order spirometry (12% vs. 18%) |
| Mandall  200550 | 2 groups with 80 patients (mean age 13.1 years) for intervention and 247 controls (mean age 13.8 years) for orthodontic screening | Electronic history and digital images taken with camera and sent via email | Dentistry | Screening | H |  |  | S | Sensitivity=0.80, and specificity=0.73 suggesting good screening test. However, low negative predictive value at 0.50. No difference between attendance for first appointment. 131/200 providers responded to survey and 70% felt teledentistry good idea. |
| Massone  200667 | Physician request for 783 requests for consultations with 285 for pigmented lesions and 440 non-specific and 58 non-melanoma skin cancer | Website allowing uploading of 3 digital images and form for patient clinical data | Dermatology | Diagnostic |  | P |  |  | Of a total 133 requests analysed, 80 (60%) were answered within one day, 47 (35%) within one week, five (4%) within two weeks and one (1%) consultation was answered in more than two weeks. |
| McConnochie  200535 | 5 inner city child care centers with avg. 138 children/centre presenting with acute illness | Computer with teleconferencing camera, digital camera and electronic stethoscope submitted by broadband | Paediatrics (acute illness) | Diagnostic and treatment | H |  | R |  | Absence due to illness (ADI) was 4.07/100 child days with telemedicine compared with 8.78/100 child-days without. 63% reduction in ADI due to telemedicine telemedicine intervention resulted in 7.0% exclusion from child care and in-person visits for 2.8%; Surveys of parents indicated 91.2% of telemedicine contacts allowed them to stay at work; 93.8% of problems managed by telemedicine would otherwise have led to an office or emergency department visit. |
| Moreno-Ramirez  200665 | 63 patients with skin lesions enrolled with 61 cases evaluated. No comparison group. | Digital clinical images and dermatoscopic images taken and submitted via intranet | Dermatology | Diagnostic | H | P | R |  | Agreement with gold standard 0.91 (95% CI 0.82–1.00) for clinical teleconsultation and 0.94 (95% CI 0.88–1.00) for teledermatoscopy (p > 0.05). Teledermatoscopy increased economic investment of teledermatology facility by 2.4 times. GP spent 1.5 times longer on dermatoscopic teleconsultations.  Teledermatoscopy improved the teledermatology-based screening system for pigmented lesions. |
| Mukundan  200336 | 8 patients from Solomon Islands referred by medical student for variety of conditions | Digital image capture of clinical lesions and patient data and submission via email | Multiple | Diagnostic |  | P |  |  | 7/8 replies received <1d and 8/8 <3d; 50 additional referrals with >2/3 responded to <24h and 80% <3d |
| Pak 199922 | 100 cases with skin lesions from referral sites including 8 primary care clinics and hospitals without dermatologists. No comparison group. | Digital image capture with camera and transmission over the Internet | Dermatology | Diagnostic |  | P | R | S | 45% of patients avoided dermatologist visit resulting in 15-20% decline in workload; 17% required follow-up with dermatologist. Most patients felt teledermatology met their healthcare needs; 27% of follow-up cases required in person visit and 73% could be followed telephonically. Consultants took 7.7 minutes (teleconsult) vs. 20 minutes (in-person) with 70% comfortable with the diagnostic impression. Patient satisfaction during follow-up much lower due to wait for real-time appointment or lack of follow-up from primary care physician. |
| Pap  200237 | 20 patients evaluated at random referred to plastic surgery service | Digital image capture of clinical lesion and radiographs with camera and transmission via email | Plastic surgery | Diagnostic |  | P |  | S | e-mail generated <10 minutes and received by attending physician <5 minutes; attending physicians reported thorough satisfaction with picture quality, the speed of transmission, and screen resolution. |
| Patterson  200151 | 12 patients (age range 15–57 years) with various neurological conditions | Digital image capture with camera and transmission via email | Neurology | Diagnostic | H |  | R |  | 8 cases considered complicated by the neurologist (preferred video-link consultation); advice beneficial in 75% of complex and in all straightforward cases; 50% patients had care changed from specialist advice and one patient transfer out of country was avoided. |
| Person  200039 | Over 200 patients with multiple conditions in first 6 months of program in Micronesia | Digital image capture with upload to Web-based system | Multiple | Diagnostic |  |  | R | S | Cost savings direct and long distance telephone charges; every patient treated at home represents savings $10-20k; “…acceptance by the referring and consulting physicians alike has been overwhelming” |
| Person  200338 | 2 girls with traumatic injuries | Not specified | Orthopaedic | Therapeutic |  |  | R |  | 2 cases illustrate cost savings and avoidance of transfer (no details provided) |
| Rodas  2005109 | 144 pre-operative and 50 post-operative patients in Cuenca | Real-time and SF using digital image capture and transmission via email over POTS | Pre and post operative assessment | Therapeutic | H | P |  |  | In 101 preoperative evaluations, agreement in 78 cases (77%); in 37 postoperative evaluations agreement in 36 cases (97%). “Telemedicine may reduce the time required on site for preoperative planning, and may provide reliable postoperative surveillance, improving the efficiency of mobile surgery services. “ |
| Sibson  199920 | 23 patients (age range 9-74 years) presenting with suspicious skin lesions | Digital image of clinical lesion and relevant history and submission via email (over ISDN) compared with face to face intervention | Dermatology | Diagnostic | H |  |  | S | 75% of patient ‘agreed’ or ‘strongly agreed’ with remote expert opinion; 77 % (n=14) of respondents either `very comfort able’ or `comfortable ’with having their lesion photographed. No respondent reported any concerns regarding the electronic transfer of their clinical information using telemedicine; 100 % clinician agreement between the diagnostic opinions from both plastic surgeons from the virtual and real mole clinics. |
| Taylor  200152 | 194 patients presenting with skin lesions | Video camera to record still images and electronic recording of patient data | Dermatology | Diagnostic | H | P | R |  | 77% agreement between diagnoses of the dermatologists using the system to inspect images and face-to-face dermatologist; fewer urgent appointments (32% compared with 64%); 31% of cases patient did not need to be seen-15% of these cases (5% of the total), however, their diagnosis differed significantly from that of the consultant who saw the patient; 14% of patients conventionally assigned a non-urgent appointment would have been seen urgently. |
| Vassallo  200153 | 27 patients across five different specialties | Digital camera to capture images and transfer via email | Multiple |  |  | P | R |  | Initial email replies were received <1d of referral in 70% of cases and <3d in 100%; consultation complete <3d in 14 cases (52%) and <3 weeks in 24 cases (89%); referral judged beneficial in 24 cases (89%); 4 patients (15% of the total) and their families were spared the considerable expense and unnecessary stress of traveling abroad for a second opinion |
| Vladzymyrskyy  200561 | 210 patients across multiple clinical domains but most related to trauma (age range from one month to 85 years) | Telemedical workstation with computer, digital camera, Web camera, email and videoconferencing | Multiple | Diagnostic |  | P |  |  | Median interval between request for a teleconsultation and it being carried out was <1d; majority of cases required single adviser; 11% of cases, more >3 advisers were required; treatment suggested by consultant accepted in 88% of cases. |
| Weinstock  200240 | 100 of 112 eligible patients with skin lesions and 19/22 primary care providers. No comparison group. | Store and forward (unspecified) | Dermatology | N/A |  |  |  | S | 42% of patients thought program excellent/good and 37% fair; 75% patients would recommend program; 87% reported teledermatologist was excellent/good--greatest concern was their lack of direct contact with their dermatologist 63% of providers rated clinic excellent/good and 21% as average; 74% rated usefulness of the program as excellent/good and would recommend the program to another provider; other concerns were wait time and follow-up--privacy concerns were not commonly mentioned. |
| White  199921 | 40 patients with skin lesions referral info vs. referral info and images. No comparison group. | Digital image captured with camera and sent with electronic patient data using wide area network over ISDN | Dermatology | Diagnostic |  | P | R | S | Patients more accurately triaged in at least 50%of cases (with image) and 25%of patients did not require outpatient dermatological appointment. Dermatologists rated image quality at 7.5 on a 10-point scale. |
| Whited  200241 | 275 patients with skin lesions with 135 randomized to intervention | Digital image capture with standardized history and electronic consult request compared with face to face | Dermatology | Diagnostic |  | P |  |  | Teledermatology arm reached a time to initial definitive intervention significantly sooner than did usual care (median 41 days versus 127 days, p<0.0001, log-rank test); 18.5% of patients in the teledermatology arm avoided need for clinic-based visit compared to zero patients in the usual care arm of the study (p=0.001, z-test). Teledermatology not cost-savings per patient ($34.60 vs. $21.40) but found to be cost-effective based on faster time to definitive treatment with teledermatology. |
| Williams  200154 | 141/195 patients with teledermatology appointments (age range 18–90 years) | Not specified | Dermatology | Diagnostic |  |  |  | S | 93% reported they were happy with the teleconsultation; 86% reported that it was more convenient than going to the outpatient clinic. 40% agreed that they would feel more comfortable seeing the dermatologist in person while only 58% were comfortable with not speaking to the dermatologist about their skin condition; absence of interaction with dermatologist and delay in receiving management advice may contribute to somewhat low satisfaction rates. |
| Zelickson  199717 | 29 nursing home residents with skin lesions compared with FTF | Video camera for image capture of lesion and still-image telephone | Dermatology | Diagnostic | H |  |  | S | 88% of cases with the history and image given correct diagnoses; no incorrect diagnoses or treatment plans would have given rise to substantial morbidity; dermatologists comfortable in making diagnosis and treatment plan in all cases with both image and patient history. |