Title: Asynchronous telehealth: Systematic review of analytic studies

Amol Deshpande, MD, MBA[1]
Shariq Khoja, MD, PhD[2]
Julio Lorca, MD[3]
Ann McKibbon, BSc, MLS, PhD[4]
Carlos Rizo, MD, PhD [5]
Alejandro R. Jadad, MD, DPhil, FRCPC[6]

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[1]Consultant, Foresight Links Corporation, Toronto, Ontario, Canada [amol.d@rogers.com]
[2]Assistant Professor, Dept of Community Health Sciences and Medical Director's Office, Aga Khan University, Karachi, Pakistan [shariq.khoja@aku.edu]
[3]General Director, Institute for Innovation on Human Well-being, Malaga, Andalusia, Spain
[4]Associate Professor (Part-Time), Health Information Research Unit, Faculty of Health Sciences, McMaster University [mckib@mcmaster.ca]
[5]Candidate, Department of Health Policy, Management and Evaluation, University of Toronto, Toronto, Ontario, Canada [crizos@gmail.com]
[6]Professor, Chief Innovator and Founder of the Centre for Global eHealth Innovation, University Health Network and University of Toronto, Toronto, Ontario, Canada [ajadad@ehealthinnovation.org]

*The "Stroke" components of this strategy are drawn from the Cochrane Stroke Group Medline search strategy.

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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Conflicts of Interest

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

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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

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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.

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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.

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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).

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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).

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Health outcomes were 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 care outcomes 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.

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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). Six[7-12] of these involved pathology (i.e., telepathology) while four[13-16] 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 seven[17-23] published before 2000.

The primary author was based in the US in 22 publications[17, 19, 22-41] while 15 publications[20, 21, 42-46, 47 , 48-54] originated from the UK. The remaining studies were distributed across various countries with Italy producing three[55-57] and two[58, 59] from The Netherlands. Canada was responsible for one publication.[60]

Study designs included three randomized control trials (RCTs)[41, 47, 50] and seven surveys[30, 40, 44-46, 54, 56] Thirty-six publications were designed as a case series, while six reports were characterized as cohort studies.

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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] four[27, 28, 34, 35] paediatrics, and two[29, 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

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development of a management plan. In one study,[66] an appropriate management plan was developed in 84% of the cases, but another study[48] 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] Massone[67] 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] Klaz[64] 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] White[21] 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

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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%). Vladymyrszki[61] 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] One[33] 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). Archbold[42] 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 three[27, 34, 35] evaluated resource use.

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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] Kokesh[31] 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 studies[41, 47] quantified costs and reported their outcomes in two[68,69] separate publications. Asynchronous telehealth was found to be less expensive than real-time teleconsultation but its clinical usefulness was limited.[68] Whited[69] 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. Eminovic[58] 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]

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In mixed (i.e., multiple) clinical domains, two publications reported an approximately 15% to 23% reduction in patient transfers.[53, 60] One Canadian study[60] 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 referrals[42] 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. Malone[34] 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. McConnochie[35] also reported fewer visits to the emergency room while Callahan[27] 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] Klaz[64] noted an 89% patient satisfaction rate with higher results in rural compared with urban areas. Two studies[45, 63] reported that 85% of patients said they would accept

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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 studies[26, 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.

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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

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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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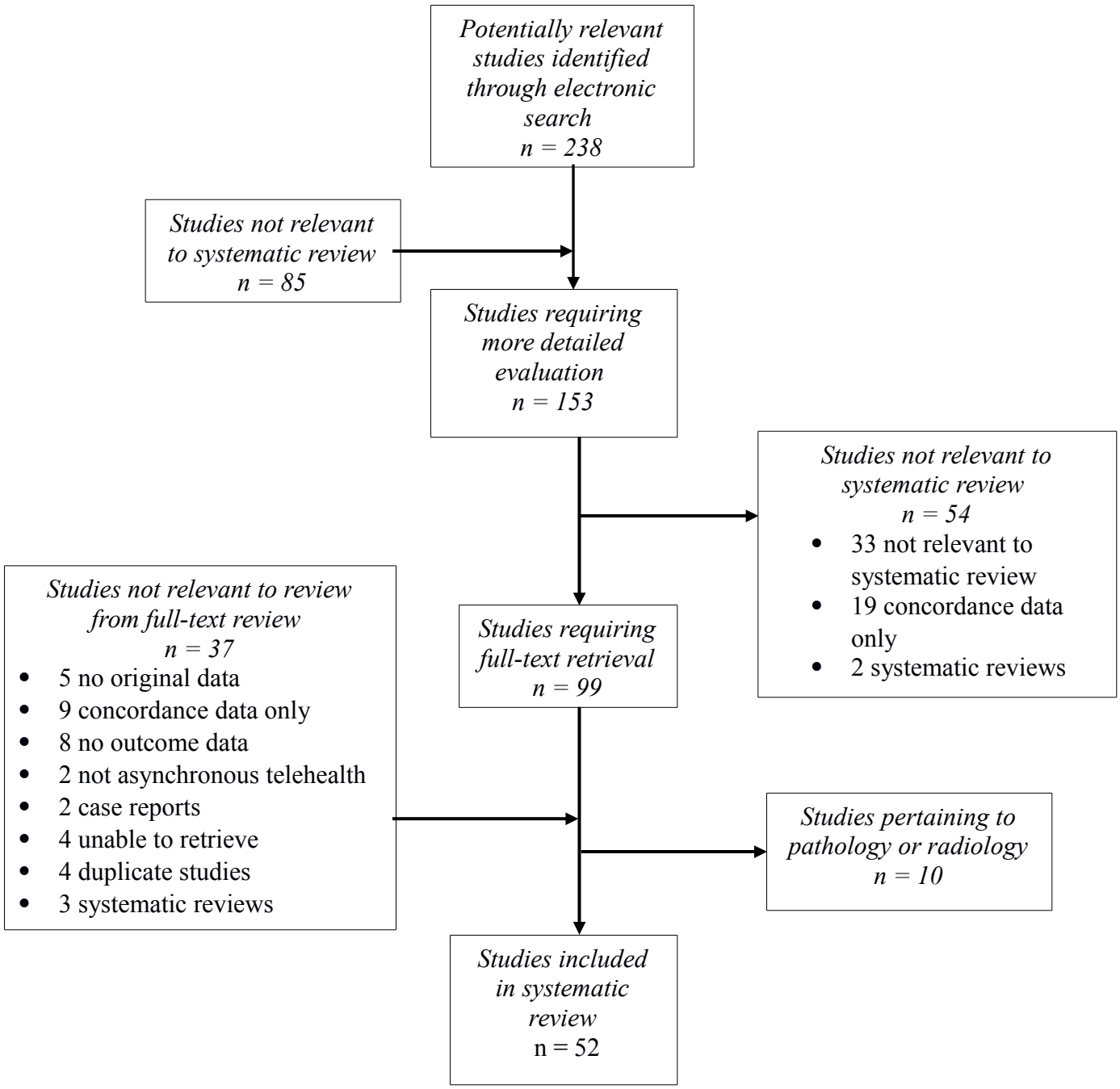
*The "Stroke" components of this strategy are drawn from the Cochrane Stroke Group Medline search strategy.

Table 1. Excluded studies from asynchronous telehealth review

Publication	Reason for exclusion
Burgess[74]	Assessed concordance only
Hill[75]	Assessed concordance only
Houston[76]	Assessed concordance only
Jones[77]	Assessed concordance only
Lattimore[78]	Assessed concordance only
Minervini[79]	Assessed concordance only
Piccolo[80]	Assessed concordance only
Szot[81]	Assessed concordance only
Sclafani[82]	Assessed concordance only
Duerinckx[83]	Did not assess asynchronous technology
Kanzaki[84]	Did not assess asynchronous technology
Sibson[85]	Duplicate study population
Demiris[86]	No original data reported
Leong[87]	No original data reported
Oakley[88]	No original data reported
Umefjord[89]	No original data reported
Whitten[90]	No original data reported
Blum[91]	Publication did not report any outcome data
Chang[92]	Publication did not report any outcome data
Dunn[93]	Publication did not report any outcome data
Gilbert[94]	Publication did not report any outcome data
Krumm[95]	Publication did not report any outcome data
Person[96]	Publication did not report any outcome data
Sanchez[97]	Publication did not report any outcome data
Sood[98]	Publication did not report any outcome data
Sussmann[99]	Publication did not report any outcome data
Munir[100]	Publication of case report
Weinstock[101]	Publication of case report
Loane[68]	Subset data from Loane [47]
Whited[69]	Subset data from Whited[41]
Whited[102]	Subset data from Whited[41]
Currell[103]	Systematic review
Whited[104]	Systematic review
Williams[73]	Systematic review
Desai[105]	Unable to retrieve full-text through multiple sources
Kuo[106]	Unable to retrieve full-text through multiple sources
Mallett[107]	Unable to retrieve full-text through multiple sources
Pavlicek[108]	Unable to retrieve full-text through multiple sources

*The "Stroke" components of this strategy are drawn from the Cochrane Stroke Group Medline search strategy.

Figure 1. QUOROM Flowchart



*The "Stroke" components of this strategy are drawn from the Cochrane Stroke Group Medline search strategy.

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

*The “Stroke” components of this strategy are drawn from the Cochrane Stroke Group Medline search strategy.

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

*The “Stroke” components of this strategy are drawn from the Cochrane Stroke Group Medline search strategy.

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

*The “Stroke” components of this strategy are drawn from the Cochrane Stroke Group Medline search strategy.

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

*The “Stroke” components of this strategy are drawn from the Cochrane Stroke Group Medline search strategy.

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	Survey	15

Author	Year of publication	Source of publication	Country	Funding source	Type of study	Quality score (DB)
				Programme		
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
Eminovic[58]	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
Heautot[18]	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

Author	Year of publication	Source of publication	Country	Funding source	Type of study	Quality score (DB)
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
Krupinski[32]	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	UK	NHS R&D	RCT	2(JS)

Author	Year of publication	Source of publication	Country	Funding source	Type of study	Quality score (DB)
		& Telecare				
Mahendran[48]	2005	Clinical &Experimental Dermatology	UK	Not reported	Case series	13
Malacarne[57]	2004	Telemedicine Journal & E-Health	Italy	Not reported	Case series	11
Mallett[49]	2003	Clinical & Experimental Dermatology Clinical and experimental dermatology	UK	Not reported	Case series	6
Malone[34]	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)
Massone[67]	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
Mukundan[36]	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

Author	Year of publication	Source of publication	Country	Funding source	Type of study	Quality score (DB)
Pap[37]	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
Person[39]	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
White[21]	1999	Journal of Telemedicine & Telecare	UK	Not reported	Case series	7
Whited[41]	2002	Telemedicine Journal and e-Health	USA	VA Health Services Research and Development Service.	RCT	2(JS)
Williams [54]	2001	Journal of Telemedicine	UK	Not reported	Survey	10

Author	Year of publication	Source of publication	Country	Funding source	Type of study	Quality score (DB)
		& Telecare				
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 2005[24]	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 2005[42]	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 2005[63]	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).

H=Health outcomes
P=Process of care
R=Resource utilization
S=Patient and provider satisfaction

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
									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 2000[25]	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 2002[55]	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

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
									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 2000[43]	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 2005[25]	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 2005[27]	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).

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
									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 2004[62]	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	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

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
	teleconsultation								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 2000[44]	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

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
									felt referral process complex while 18/33 reported increased workload
Eminovic 2003[58]	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 2003[60]	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)-	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 %

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
	unknown								unnecessary patient transfers avoided. non-urgent advice requests increased from 0 to 21 %. ATM network, the service gave satisfaction to all the physicians.
Helveston 2001[29]	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 2002[30]	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 2004[66]	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 2005[64]	18 physicians in military units recruiting 435 patients (age range 18-39 years) from rural	Digital images uploaded from camera and sent along with electronic	Dermatology	Diagnostic		P	R	S	Tele-diagnosis possible for 95% of 435. 22% of referrals required face-to-face consultation. Satisfaction

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
	and urban centres with non-pigmented skin lesions. No comparison group.	questionnaire via email							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"

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
Krupinski 2004[32]	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 1999[19]	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 2003[56]	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

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
									satisfaction:78% of sessions set goal was reached
Lau 2002[33]	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 2000[47]	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 2005[48]	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 2004[57]	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	727 images on 325	Digital image capture	Dermatology	Diagnostic	H		R		95% concordance with

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
2003[49]	referrals (age range 4 months-94 years) with variety of skin lesions. Face-to-face comparison.	with camera and transmission via email over ISDN							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 2004[34]	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 2005[50]	2 groups with 80 patients (mean age 13.1 years) for intervention and 247 controls (mean age 13.8 years) for	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

H=Health outcomes
P=Process of care
R=Resource utilization
S=Patient and provider satisfaction

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
	orthodontic screening								attendance for first appointment. 131/200 providers responded to survey and 70% felt teledentistry good idea.
Massone 2006[67]	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 2005[35]	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 2006[65]	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

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
									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 2003[36]	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 1999[22]	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

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
									or lack of follow-up from primary care physician.
Pap 2002[37]	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 2001[51]	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 2000[39]	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 2003[38]	2 girls with traumatic injuries	Not specified	Orthopaedic	Therapeutic			R		2 cases illustrate cost savings and avoidance of transfer (no details provided)
Rodas 2005[109]	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%).

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
									"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 1999[20]	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 2001[52]	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

Publication	Sample	Intervention	Clinical Domain	Level of care	Outcome category				Results
					H	P	R	S	
									of the consultant who saw the patient; 14% of patients conventionally assigned a non-urgent appointment would have been seen urgently.
Vassallo 2001[53]	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 2005[61]	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 2002[40]	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

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					H	P	R	S	
									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 1999[21]	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 2002[41]	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-

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					H	P	R	S	
									savings per patient ($34.60 vs. $21.40) but found to be cost-effective based on faster time to definitive treatment with teledermatology.
Williams 2001[54]	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 1997[17]	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.