Asynchronous telehealth: a scoping review of analytic studies

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ABSTRACT

Background: Asynchronous telehealth captures clinically important digital samples (e.g., still images, video, audio, text files) and relevant data in one location and subsequently transmits these files for interpretation at a remote site by health professionals without requiring the simultaneous presence of the patient involved and his or her health care provider. Its utility in the health care system, however, still remains poorly defined. We conducted this scoping review 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 the use 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, category of outcome, and results. Study quality (internal validity) was assessed using the Jadad scale for randomized controlled trials and the Downs and Black index for non-randomized studies. Summary data were categorized by medical specialty and presented qualitatively.

Results: The scoping review included 52 original studies from 238 citations identified; of these 52, almost half focused on the use of telehealth in dermatology. 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: A significant portion of the asynchronous telehealth literature involves its use in dermatology. Although the quality of many original studies remains poor, at least within dermatology, 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 better) diagnostic accuracy when compared with face-to-face consultations. With the exception of a few studies in pediatric asthma, the impact of this intervention on individual health outcomes remains unknown.

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The need to deliver services to remote and underserved communities has been the main impetus behind the expansion of telehealth programs. Telehealth services that rely on real-time consultations, however, are realizing that their need to interact with dedicated, specialized facilities is limited by factors similar to those 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 toward a model that continues to rely on a physician's real-time presence — a scarce commodity, given changing demographics and the lifestyle choices of physicians.[1,2]

One form of telehealth, known as asynchronous (or store-and-forward) telehealth, helps provide administrative and support services to areas that lack health professionals who can meet the needs of the population locally. Because of the widespread penetration of technologies such as the Internet, personal digital assistants (PDAs), smart phones (voice-centric handheld devices that function as phones and as PDAs), and digital photography, and in view of reductions in the cost of data storage, patients and health professionals can capture clinically important digital samples and relevant data (e.g., pictures of moles or surgical wounds, electrocardiograms, spirometry results, radiological images) in various formats (e.g., audio, video, text) from any location and send them to health professionals at distant sites for assessment at a convenient time. The independence of this digitized information from real-time interactions between patients and health professionals, together with the low cost of the required infrastructure, could allow asynchronous telehealth to reduce wait times, provide opportunities to rethink 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 scoping 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, Canada).

Literature search strategy. An information specialist (ME) prepared a detailed search strategy (online Appendix 1) combining 3 clusters of terms: the first focused on telehealth, the second on asynchronous forms of electronic communication, 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 of the following criteria:

- evaluated 1 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 2 reviewers (AM and CL, and 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 observa-

tional, the study was recorded as a case series, a cross-sectional effort, a cohort or a case-control study; where relevant, it was stated whether the study was identified as retrospective or prospective
- technological characteristics of the telehealth platform (e.g., Integrated Services Digital Network [ISDN]- or Internet Protocol [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 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 (CCTs).[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 used only for qualitative studies and CCTs, we used a modified score with "0" or "1," according to 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] RCTs were considered to be of 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 that met the inclusion criteria, based on 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 for the present review, given the clinical heterogeneity of the included studies. 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 (see online Appendix 2).

From the remaining 62 publications, 10 were excluded because they did not involve medical areas traditionally associated with direct patient care. Six[7-12] of these involved pathology, while 4[13-16] addressed applications for use in radiology. Agreement between reviewers was high, although no formal statistical measure was completed.

A summary of the selection process is presented in Figure 1.

Study characteristics. Fifty-two studies were included in this review; of these, 7[17-23] were published before 2000. The study characteristics are presented in Tables 1 and 2.

The primary author was based in the United States for 22 studies[17,19,22-41] and in the United Kingdom for 15.[20,21,42-46,47,48-54] Primary authors for the remaining publications were based in a number of countries, with 3 from Italy[55-57] and 2 from the Netherlands.[58,59] One study originated in Canada.[60]

Study designs included 3 RCTs[41,47,50] and 7 surveys.[30,40,44-46,54,56] Thirty-six publications were designed as case series studies, while 6 were characterized as cohort studies.

In 24 publications, no funding source for the study was documented.

Dermatology was the most frequently represented medical specialty (24 publications). Nine articles reported data based on results identified across various medical specialties;[19,23,26,36,39,53,57,60,61] 6 reported on musculoskeletal medicine,[24,33,38,42,43,55] 4 on pediat-

rics,[27,28,34,35] and 2 on ophthalmology.[29,62] Other clinical settings included plastic surgery and the neurological sciences.

Quality assessment. One of 3 RCTs was judged to be of high quality[50] (see Table 1). Of the remaining 49 studies, 15 received high-quality ratings.[20,24,25,28,35,40,42,45,46,52,58,62-65]

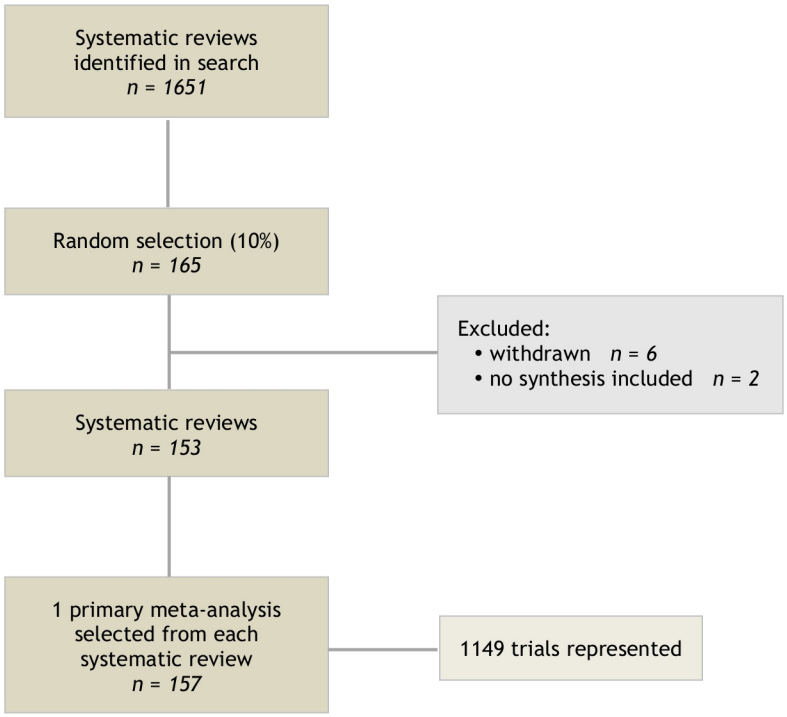

Figure 1: Selection of studies for scoping review

Data analyses and synthesis

Dermatology. Many publications in this group addressed more than 1 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 with the use of telehealth in dermatology. One study reported that diagnostic accuracy for teleconsultants as a group was obtained in 73% of all cases of skin lesions and in 90% of evaluations of skin cancer lesions.[25] Other reports documented rates of diagnostic accuracy varying from 75% to 88%.[17,52,63] Combining images from asynchronous telehealth with standard patient histories increased diagnostic accuracy to 90% and 82% ($p < 0.001$) for 2 teledermatologists.[63] The level of agreement with the gold standard (face-to-face consultation) was 0.91 (95% confidence interval [CI] 0.82-1.00) for clinical consultations using telehealth and 0.94 (95% CI 0.88-1.00) for dermatoscopy using telehealth ($p > 0.05$).[65] Discrepancies were reported in the ability of asynchronous telehealth to contribute to the development of a management plan. In 1 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. Of the 9 publications that assessed process-of-care outcomes, most studies reported a reduction in time to consultation. The average time between referral and clinical advice was reported to be 46 hours (range 17-119, standard deviation [SD] 24) in 1 publication.[66] Massone reported that, of 133 requests analyzed, 80 (60%) were answered within a day.[67] The use of telehealth in dermatology resulted in a time to initial definitive intervention that was significantly shorter than that of usual care (median 41 days v. 127 days, $p < 0.0001$); 25 patients (18.5%) in the telehealth arm avoided the need to visit a dermatology clinic.[41] Klaz noted that the average wait times for asynchronous telehealth consultations (n = 435) were 50% less than those for face-to-face consultation.[64] The time to perform a consultation was also affected by the use of asynchronous telehealth: the time to complete a telehealth consultation was 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 20 of the 40 (50%) cases. Telehealth use in dermatology also resulted in 14% of non-urgent referrals being upgraded to urgent, while another 24 of 136 (17%) were deemed to need assessment when none was planned.[52,59]

The use of asynchronous telehealth in dermatology decreased the frequency of in-person visits or avoided them altogether. Eminovic[58] reported that 56 of 96 (58%) 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 the use of telehealth in dermatology resulted in the avoidance of 45% of in-person visits, producing a 15%-20% decline in workload.[22]

Resource utilization. Eleven publications on the use of telehealth in dermatology reported outcomes pertaining to resource use. Two studies[41,47] quantified costs and reported their outcomes in 2[68,69] separate publications. Asynchronous telehealth was found to be less expensive than real-time telehealth consultations, but its clinical usefulness was limited.[68] Whited[69] noted that the use of telehealth in dermatology was not associated with cost-savings but seemed to be cost-effective when the faster time to definitive treatment was taken into account.

User satisfaction. Patient or provider satisfaction in general was determined to be high in 11 publications assessing telehealth in dermatology. Ninety-three percent of patients reported that they were happy with telehealth consultations.[54] Klaz[64] noted an 89% patient satisfaction rate with higher results in rural areas than in urban areas. Two studies[45,63] reported that 85% of patients said they would accept the use of telehealth in dermatology in the future, 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 telehealth 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] A more recent report documented 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 the use of telehealth in dermatology, while 47% were dissatisfied and 32% were unsure. The most common reasons cited for negative responses were complex process and increased workload.

Studies involving multiple medical specialties. *Health outcomes.* Among the 9 articles in this group, none presented data on individual patient health outcomes for any of the medical specialties.

Process of care. Articles generally reported that less time was needed to process referrals. Most asynchronous telehealth cases (67%) had a total turn-around time of less than 72 hours, and the average turn-around time for store-and-forward cases was almost 40% faster than for real-time telehealth.[19] Replies within 1 day of referral were provided in 70%-87.5% of cases and within 3 days of referral in 100% of cases.[36,53] Actual telehealth consultations were completed within 3 days in 14 cases (52%) and within 3 weeks in 24 cases (89%). Vladymyrszki[61] reported that the median interval between a request for consultation using telehealth services and it being conducted was less than 1 day, with an acceptance of treatment results in 88% of cases.

In mixed (i.e., multiple) medical specialities, 2 studies reported an approximate 15%-23% reduction in patient transfers.[53,60] One Canadian study[60] reported that of the 101 patients evaluated, 8 emergency transfers were avoided, and 15 patients who would have required elective transfer were managed locally via telehealth. 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]

Resource utilization. Among the 9 articles in this group, none were identified that presented data on the impact of asynchronous telehealth on the use of resources.

User satisfaction. Three studies[26,39,60] involving multiple medical specialties 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]

Orthopedics. Five publications in the area of musculoskeletal medicine assessed trauma or injury.[24,38,42,43,55] One study focused on postoperative recovery after shoulder surgery.[33]

Health outcomes. One study assessed the validity of asynchronous telehealth, noting minimal diagnostic disagreement (5% intra-observer 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 results of all imaging of the injury revealed that initial descriptions submitted by the referring physician were inaccurate with respect to the nature of the injury.

Process of care. The 1 study that assessed process of care documented that the average time spent by orthopedic specialists was longer in videoconferencing (21 minutes, SD 8) than in asynchronous telehealth consultations (19 minutes, SD 8). However, a clinician's

Table 1: Characteristics of studies included in the scoping review

Study	Country	Funding source	Type of study	Quality score*
Abboud 2005[24]	USA	Not reported	Case series	19
Archbold 2005[42]	UK–Ireland	Vodaphone	Case series	16
Baba 2005[63]	Turkey	Not reported	Case series	18
Barnard 2000[25]	USA	Not reported	Case series	15
Baruffaldi 2002[55]	Italy	Not reported	Case series	10
Beach 2000[43]	UK	NHS Executive (telemedicine equipment loaned by ADV Communications and software by Telemarque Ltd.)	Case series	6
Brandling-Bennett 2005[26]	USA	Not reported	Case series (retrospective)	13
Callahan 2005[27]	USA	US Army Medical Research Acquisition	Case series	12
Chan 2003[28]	USA	US Army Research Acquisition activity	Case series	17
Chen 2004[62]	Taiwan	Not reported	Case series	14
Collins 2004[46]	UK	NHS R&D Health Technology Assessment Programme	Survey	15
Collins 2004[45]	UK	UK NHS R&D Health Technology Assessment Programme	Survey	17
Collins 2000[44]	UK	NHS R&D Health Technology Assessment Programme	Survey	12
Eminovic 2003[58]	Netherlands	KYOS Research Foundation (non-profit organization)	Cohort (prospective)	19
Fortin 2003[60]	Canada	Health Canada Transition Fund	Case series and semi-structured interview	13
Gomez 1996[23]	USA	Not reported	Cohort (retrospective)	10
Heautot 1999[18]	France	Ministry of Industry, the Region of Brittany	Case series	8
Helveston 2001[29]	USA	Equipment sponsor Education and Research Foundation for Children's Eyes, Indianapolis, Ind., and Clody and Riley's "One-Eyed Golf"	Case series (before/after)	8
Hersh 2002[30]	USA	Eugene Garfield Foundation, OHSU Hospital, OHSU Medical Group, and Asante Health System	Survey	12
Hockey 2004[66]	Australia	Commonwealth Department of Health and Ageing (Medical Specialist Outreach Assistance Programme)	Case series	11
Klaz 2005[64]	Israel	Israel Defense Forces Medical Corps	Multicentre uncontrolled cohort (prospective)	18
Knol 2006[59]	Netherlands	Not reported	Cohort (prospective)	13
Kokesh 2004[31]	USA	Not reported	Case series (descriptive)	2
Krupinski 1999[19]	USA	US Department of Agriculture Rural Utilities Service Distance Learning, US Department of Commerce, National Telecommunications and Information Administration, Office of Rural Health Policy, Department of Health and Human Services Rural	Case series	12

Study	Country	Funding source	Type of study	Quality score*
Krupinski 2004[32]	USA	Not reported	Cohort (retrospective)	12
Larcher 2003[56]	Italy	Public Health Institute of the Government of Italy	Survey	13
Lau 2002[33]	USA	Not reported	Case series (descriptive)	9
Loane 2000[47]	UK	NHS R&D	RCT	2†
Mahendran 2005[48]	UK	Not reported	Case series	13
Malacarne 2004[57]	Italy	Not reported	Case series	11
Mallett 2003[49]	UK	Not reported	Case series	6
Malone 2004[34]	USA	Pacific Telehealth and Technology Hui and medical health care facilities	Case series	12
Mandall 2005[50]	UK	Not clearly stated	RCT	3†
Massone 2006[67]	Austria	Not reported	Case series (descriptive)	7
McConnochie 2005[35]	USA	US Department of Commerce Technology Opportunities Program, Robert Wood Johnson Foundation Local Initiative Funding	Case series (before and after)	15
Moreno-Ramirez 2006[65]	Spain	Instituto Carlos III of the Spanish Health Ministry	Case series	14
Mukundan 2003[36]	USA	Swifen Charitable Trust, Canterbury, UK	Case series	11
Pak 1999[22]	USA	Walter Reed Army Medical Center	Cohort (retrospective)	10
Pap 2002[37]	USA	Not reported	Case series	11
Patterson 2001[51]	UK	Not reported	Case series	12
Person 2003[38]	USA	The Pacific Island Health Care Project	Case reports	6
Person 2000[39]	USA	Not reported	Case series	6
Rodas 2005[109]	Ecuador	NASA and Instituto de Investigaciones de la Universidad de Cuenca	Case series	11
Sibson 1999[20]	UK	NHS Research and Development Waiting List Taskforce fund	Case series and survey	15
Taylor 2001[52]	UK	Not reported	Case series	17
Vassallo 2001[53]	UK	Swinfen Charitable Trust, Canterbury, UK	Case series	12
Vladzymyrskyy 2005[61]	Ukraine	Not reported	Case series	8
Weinstock 2002[40]	USA	Cooperative Studies Program, Office of Research and Development, Department of Veterans Affairs	Survey	14
White 1999[21]	UK	Not reported	Case series	7
Whited 2002[41]	USA	VA Health Services Research and Development Service	RCT	2†
Williams 2001[54]	UK	Not reported	Survey	10
Zelickson 1997[17]	USA	Not reported	Case series	13

*Assessed using Downs and Black index unless otherwise noted; †Assessed using Jadad score; RCT = randomized controlled trial.

Table 2: Components and outcomes of studies included in the scoping review

Study	Sample	Intervention	Clinical domain	Level of care	Outcome category				Results
					H	P	R	S	
Abboud 2005[24]	100 patients aged 8–79 yr 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	Orthopedic	Diagnostic	H				5.0% intra-observer differences and 5.5% inter-observer in diagnoses or treatment when comparing 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 for patients aged 4–90 yr	Multi-media cellphone to capture images (mobile platform) including plain films and wound	Orthopedic	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 of 46 cases (trauma surgeon) and 36 of 46 cases (emergency physician). Ease of use acceptable 70% of the time.
Baba 2005[63]	242 skin lesions on 228 patients aged 2–82 yr	PC-based Web camera videoconferencing compared with electronic transfer of history and images obtained with digital camera	Dermatology	Diagnostic	H			S	Conventional store-and-forward method diagnostic accuracy of 2 teledermatologists 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 telehealth for dermatology in the future; of these, 82% thought telehealth consultation should include videoconferencing with Web cameras.
Barnard 2000[25]	8 dermatologists using telehealth evaluated 50 cases, involving various skin conditions, submitted by other dermatologists	Digital images taken with camera of lesions followed by brief electronic history	Dermatology	Diagnostic	H				Diagnostic accuracy for skin cancers was 88% versus 90% (range 75%–100%) for in-person and telehealth consultants, respectively. For all confirmed cases the accuracy was 84% (in-person) compared with 73% (range 65%–88%). Telehealth consultants changed their primary diagnosis in 11% of cases (range 2%–22%). Biopsy rates were not significantly different between telehealth consultants (45%) and in-person dermatologists (40%).

Study	Sample	Intervention	domain	Level of care	H	P	R	S	Results
Baruffaldi 2002[55]	65 telehealth consultations for second opinion on work-related injuries	Real-time VC (PC with document camera) or asynchronous with transfer of files across ISDN	Orthopedic	Diagnostic		P			Average time spent was slightly longer in videoconferences (21 min., SD 8) than in asynchronous telehealth consultations (19 min., SD 8). The clinicians' confidence in diagnosis was lower in asynchronous telehealth 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 there were some concerns about the diagnostic quality of the information transmitted.
Beach 2000[43]	71 patients entering minor injury units	Low-cost VC and asynchronous telehealth transmitted over ISDN (no detailed data provided)	Orthopedic	Diagnostic			R		Data obtained in some cases avoided transfer or referral. Some changes in diagnosis and treatment for remote physicians (no detailed data provided).
Brandling-Bennett 2005[26]	264 general clinic visits on 214 patients (age range 3 mo to 80 yr) 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 US$0.63.
Callahan 2005[27]	267 pediatric consultations from 16 different sites; mean age 5 (SD 5) yr	Web-based, store-and-forward, asynchronous, provider-provider telehealth consultation with image capture device (digital camera, scanner, and video camera)	Pediatrics	Diagnostic	H	P	R		Mean response time by a consultant was 32 (SD 14) h. 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 = 0.01 for all). Routine air evacuations were avoided in 32 cases (12%).
Chan 2003[28]	10 children (age range 6-17 yr) 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	Pediatrics (asthma)	Therapeutic	H			S	Inhaler technique scores improved significantly (87% in period 1) compared with period 2 (94%). Less controller medication period 1, mean 0.8 (SD 0.6) compared with 0.5 (SD 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 telehealth monitoring.

Study	Sample	Intervention	domain	Level of care	H	P	R	S	Results
Chen 2004[62]	113 patients (mean age 53 yr) screening for ocular disorders in Tungyin, China	Digital ophthalmoscopy with image capture and transmission over ADSL	Ophthalmology	Diagnostic (screening)	H				In screening for retinopathy, the detection rate with digital imaging (8.8%) was 2 times higher than with indirect ophthalmoscopy (4.4%). Community-based screening for 4 categories of eye disease successfully demonstrated.
Collins 2004 [45]	148 responses from 208 dermatology patients enrolled in RCT comparing traditional in-person care to telehealth consultation	Asynchronous telehealth (not specified)	Dermatology	Diagnostic				S	No statistical difference in satisfaction of care between 2 groups. 85% of telehealth consultation group were happy to use this system, 38% preferred to discuss their skin problem with dermatologist in person. 40% felt that something important was missing if they did not see the dermatologist in person. 76% said they would rather have their skin problem managed via telehealth than to wait.
Collins 2000[44]	26 responses from a total of 35 GPs who agreed to participate in RCT	Asynchronous telehealth (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 for telehealth in dermatology were high. One in 4 respondents (27%, n = 7; 95% CI 9%–45%) felt confident or very confident about the diagnosis and management generated through telehealth for dermatology.
Collins 2004 [46]	36/42 GPs enrolled in an RCT responded to a before-and-after questionnaire	Asynchronous telehealth (not specified)	Dermatology	Diagnostic				S	86% were enthusiastic about telehealth for dermatology, in contrast to 21% at end of study who felt all expectations had been met; 21% were satisfied, 47% dissatisfied and 32% unsure; 31% were 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 2003[58]	96/105 patients recruited 4 mo to 72 yr) with various skin lesions	Submission of electronic form and 4 digital images taken by patient	Dermatology	Diagnostic	H		R		In 71% of cases further investigation was proposed. 58% of cases needed (less frequent) in-person consultation. For 23% of patients no kind of hospital visit was 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.

Study	Sample	Intervention	domain	Level of care	H	P	R	S	Results
Gomez 1996 [23]	240 consults from 12 remote telehealth 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 telehealth response criteria (24 h for routine consults and 3 h for emergencies).
Heautot 1999 [18]	Patients presenting for emergency neurosurgical consults at distant hospital. 3 phases: (I) 11 patients (no asynchronous); (II) 51 cases (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, of which 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 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 email was trouble-free, and communication in English was effective. The store-and-forward technique was found to be a relatively simple, inexpensive and versatile method of telehealth.
Hersh 2002[30]	31 clinicians in Oregon given access to a system to pose clinical questions	Web-based asynchronous application	Non-specific	Supportive (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			In majority (53/63) of cases management plan was developed based on email; in 10 cases (16%) additional images or biopsy results were requested (image quality inadequate). Average time between receipt of referral and clinical advice being provided was 46 h. GPs made more referrals the longer they stayed in study.
Klaz 2005[64]	18 physicians in military units recruiting 435 patients (aged 18-39 yr) with non-pigmented skin lesions from rural and urban centres. No comparison group	Digital images uploaded from camera and sent along with electronic questionnaire via email	Dermatology	Diagnostic		P	R	S	Diagnosis using telehealth possible for 95% of the 435 cases. 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 with 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 (aged 0-96 yr) with skin	Electronic form and digital image transmission by email	Dermatology	Diagnostic	H	P	R		No difference between initial diagnosis and face-to-face consultation in those requiring further follow-up. 163 patients were not

Study	Sample	Intervention	domain	Level of care	H	P	R	S	Results
	lesions. Face-to-face comparison only for those requiring follow-up								referred because of telehealth — a reduction of 53% (163/306); 17% of cases actually required traditional consultation when the GP had determined none was necessary.
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 savings to Medicaid. Of 91 cases, 79 saved transport for the patient and escort at an average round-trip cost of $307.57/person. For every $1 spent on reimbursement for telehealth, almost $8 of travel cost was avoided. Wait times from 4-15 mo were reduced "significantly."
Krupinski 2004[32]	Comparison of 50 dermatology patients assessed by telehealth with convenience sample of 50 assessed by face-to-face consultation	Digital image captured with camera and uploaded to proprietary software	Dermatology	Diagnostic			R		In-person group had fewer records about actions taken as a result of the consultation (e.g., performed a biopsy, prescribed a medication): 12% of the in-person records compared with 43% in telehealth ($p < 0.01$). Both groups had similar follow-up rate: 8% v. 10% ($p > 0.05$).
Krupinski 1999[19]	Unknown sample size. Based on review of program workload of 35 cases/mo 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 h (mean 93.01 h, SD 142.43) compared with real-time cases (28%) with a total turn-around time of < 72 h (mean = 242.71 h, SD 271.63; t = 8.051, df = 498, $p = 0.0001$). Main difference occurred in time from notification of consultant until consultation (RT mean = 175.05 h v. SF 36.62 h) SS: (t = 8.52, df = 498, $p = 0.0001$).
Larcher 2003[56]	Two questionnaires with response rate of 33/35 and 22/38 physicians before and after performing 98 asynchronous telehealth consultations with cancer patients	Web-based telehealth (no details provided)	Oncology	Diagnostic/ therapeutic/ supportive				S	Both modalities of telehealth consultation 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: in 78% of sessions the set goal was reached.
Lau 2002[33]	6 patients (average age 59 yr) followed post-operatively after shoulder surgery	Web-based messaging system to send multimedia information and implement Web forms	Orthopedic	Rehabilitative/ follow-up (post-operative)				S	User satisfaction between neutral and satisfied, with overall mean rating 3.4 out of 5 (SD = 0.85).

Study	Sample	Intervention	domain	Level of care	H	P	R	S	Results
Loane 2000[47]	204 patients (aged 4 mo to 89 yr) randomized into 2 groups of 102 patients each with various skin lesions	Real-time telehealth for dermatology (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 telehealth dermatology consultations required at least 1 other hospital appointment, as compared with 45% of conventional outpatients and 69% of store-and-forward consultation. The latter was less expensive (€22.11 v. €61.03) but clinical usefulness was limited. Sensitivity analysis showed that real-time telehealth was as economical as conventional care when less artificial assumptions were applied.
Mahendran 2005[48]	163 patients presenting with 1 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 consultations using telehealth (22% could have avoided face-to-face consultation 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 1 consultation was sufficient. Choosing the right specialist was the most critical phase of the operation.
Mallett 2003[49]	727 images on 325 referrals (age 4 mo to 94 yr) 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 telehealth. An "advice-only" service was requested and given for only 26 patients (8%), while 256 patients required an outpatient visit (i.e., the majority of patients still needed to be seen in the outpatient clinic). Telehealth unlikely to have significant impact on patient workload or to solve waiting list problems.
Malone 2004[34]	7 patients (mean age 11.9 [SD 3.7] yr) with asthma	Web-based asthma pathway with MPEG video and spirometry	Pediatrics (asthma)	Therapeutic and supportive	H		R		Fewer ED visits for asthma (mean [SD] 3.85 [5.14], range 0–15 v. 0 visits, $p < 0.05$). Fewer unscheduled acute clinic visits (mean [SD]: 1.57 [1.27], range 0–4 v. 0.286 [0.48], $p < 0.05$) in study year versus preceding year. 2 hospitalizations in year prior, 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% v. 18%).
Mandall 2005[50]	2 groups of 80 patients (mean age 13.1 yr) for intervention and 247 controls (mean 13.8 yr)	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.

Study	Sample	Intervention	domain	Level of care	H	P	R	S	Results
	for orthodontic screening								131/200 providers responded to survey, and 70% felt that teledentistry was a good idea.
Massone 2006[67]	Physician request for 783 requests for consultations; 285 were pigmented lesions, 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 1 d, 47 (35%) within 1 wk, 5 (4%) within 2 wks, and 1 (1%) consultation in more than 2 wks.
McConnochie 2005[35]	5 inner city child care centres with average of 138 children/centre presenting with acute illness	Computer with teleconferencing camera, digital camera and electronic stethoscope submitted by broadband	Pediatrics (acute illness)	Diagnostic and treatment	H		R		Absence due to illness (ADI) was 4.07/100 child-days with telemedicine as compared to 8.78/100 child-days without. A 63% reduction in ADI was attributable 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 teledermatoscopy (p > 0.05). Teledermatoscopy increased economic investment of teledermatology facility by 2.4 times. GPs 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 within < 1 d and 8/8 < 3 d; 50 additional referrals with > 2/3 responded to < 24 h and 80% < 3 d .
Pak 1999[22]	100 cases with skin lesions referred from 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 health care needs; 27% of follow-up cases required an in-person visit, and 73% could be followed telephonically. Consultants took 7.7 minutes (teleconsultation) v. 20 minutes (in-person); 70% were comfortable with the diagnostic

Study	Sample	Intervention	domain	Level of care	H	P	R	S	Results
									impression. Patient satisfaction during follow-up was much lower due to wait for real-time appointment 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	Email 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 yr) 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 1 patient transfer out of country was avoided.
Person 2000[39]	Over 200 patients with multiple conditions in first 6 mo 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 represented savings of $10 000 to $20 000; "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, Ecuador	Real-time and store-and-forward 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 1999[20]	23 patients (age range 9-74 yr) 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 patients "agreed" or "strongly agreed" with remote expert opinion; 77% (n = 14) of respondents were "very comfortable" or "comfortable" with having their lesion photographed. No respondent reported concerns regarding electronic transfer of their clinical information using telemedicine; there was 100% diagnostic agreement between plastic surgeons from the virtual and face-to-face 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 in diagnosis between dermatologists using the system to inspect images and dematologists consulting face-to-face; fewer urgent appointments (32% compared with 64%); in 31% of cases, patient did not need

Study	Sample	Intervention	domain	Level of care	H	P	R	S	Results
									to be seen, but in 15% of these cases (5% of the total), 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 classified as urgent with the use of telehealth.
Vassallo 2001[53]	27 patients across 5 different specialties	Digital camera to capture images and transfer via email	Multiple			P	R		Initial email replies received < 1 d of referral in 70% of cases and < 3 d in 100%; consultation complete < 3 d in 14 cases (52%) and < 3 wks 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 travelling abroad for a second opinion.
Vladzymyrskyy 2005[61]	210 patients across multiple clinical domains but most related to trauma (age 1 mo to 85 yr)	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 < 1 d; majority of cases required single adviser; in 11% of cases, more than 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% would recommend program; 87% reported teledermatologist was excellent/good — greatest concern was 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 times and follow-up; privacy concerns were not commonly mentioned.
White 1999[21]	40 patients with skin lesions referral info v. 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, of whom 135 were randomized to intervention	Digital image capture with standardized history and electronic consult request compared with face-to-face consultation	Dermatology	Diagnostic		P			Teledermatology arm reached a time to initial definitive intervention significantly sooner than did usual care (median 41 d versus 127 d, $p < 0.0001$, log-rank test); 18.5% of patients in the teledermatology arm avoided need for clinic-based visit compared to no patients in the usual care arm of the study ($p = 0.001$, z-test). Teledermatology did not produce cost-savings

Study	Sample	Intervention	domain	Level of care	H	P	R	S	Results
									per patient ($34.60 v. $21.40) but was found to be cost-effective based on faster time to definitive treatment with teledermatology.
Williams 2001[54]	141/195 patients with teledermatology appointments (age 18-90 yr)	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	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.

H = health outcomes; P = process of care; R = resource utilization; S = patient and provider satisfaction; SD = standard deviation; GP = general physician; ISDN = integrated services digital network; DICOM = diagnostic imaging and communications system; ATM = asynchronous transfer mode; VC = videoconference/video teleconference; MPEG = Moving Pictures Expert Group.

confidence in the diagnosis was generally lower with asynchronous consultations.[55]

Resource utilization. Studies in orthopedics 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]

Pediatrics. All studies in this group reported health outcomes, while 3[27,34,35] evaluated resource use.

Health outcomes. The use of asynchronous telehealth for pediatric care was associated with positive health outcomes. Two studies, with a combined sample of 17 patients, assessed the effect of asynchronous telehealth in pediatric 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 sickness with the use of telehealth.[35]

Process of care. Three pediatric studies reported a decrease in health care use. Malone[34] noted a drop in emergency department visits (mean [SD] 3.85 [5.14], versus 0 visits, $p < 0.05$) and admissions (mean [SD] 1.57, [1.27], versus 0.286 [0.48], $p < 0.05$) compared with the year before. McConnochie[35] also reported fewer visits to the emergency department, while Callahan[27] reported avoidance of air evacuation in 12% of the population.

Other conditions. *Health outcomes*. Two studies focused on ocular conditions. Diagnostic agreement was reported in 12 of 15 cases that presented with strabismus.[29] Another study, in which a digital ophthalmoscope was used to screen for retinopathy, showed a detection rate twice as high with digital imaging (8.8%) compared with indirect ophthalmoscopy (4.4%).[62]

Process of care. One study, which assessed the provision of nonsurgical oncology consultations to underserved communities, reported that the use of synchronous and asynchronous telehealth resulted in enhanced communication with colleagues (86% and 80% respectively).[56] Kokesh[31] documented that the use of asynchronous telehealth for ear, nose, and throat disorders reduced wait times of 4 to 15 months "significantly," although specific data were not provided.

Similar findings were noted in neurological conditions, where the treatment plan was changed in 50% of the cases as a result of the specialist's advice and 1 transfer of a patient out of the country was avoided.[51] The use of asynchronous telehealth to transmit imaging in the context of neurosurgical evaluation reduced the need to transfer a patient by 50%.[18]

Resource utilization. One study was identified in this group as providing utilization data. 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 in travel costs could be avoided.

Discussion

Similar to telehealth literature reviewed elsewhere,[70-72] the original literature in this review was of low methodological quality. Most publications did not appear to follow sound methodological principles, or described results based on small sample sizes that would be consistent with feasibility studies or pilot projects. However, despite the poor quality of evidence, certain trends were consistent 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 pediatric 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 telehealth in the management of chronic conditions.[70]

Several publications, most on the use of telehealth in dermatology and some that assessed multiple medical specialties, 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 times was significant relative to face-to-face care, decreasing by almost 50%.[64] Improved triage facilitated the prioritization of patients on the basis of urgency, thus enhancing workflow logistics. It remains unclear whether triage led to overall faster care or improved health outcomes. It is also unknown whether the expectation of faster and more effective care could be met if asynchronous technology were expanded beyond small pilot projects and feasibility studies.

The results of this scoping review are consistent with previous findings that the methods to assess the cost-effectiveness of telehealth are poor.[71] Most evidence for cost savings is implied through indirect reductions 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, al-

though not insignificant, are variable and are correlated with travel distance; thus, it could be difficult to demonstrate cost-effectiveness in more urban areas. Other studies reported a decreased frequency or avoidance of patient transfers. This was most notable in the triage of surgical cases in orthopedics 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 found to be generally above 80% for the use of telehealth in dermatology, 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: compared with primary care providers, consultants were more amenable to the use of telehealth in dermatology. 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.

Limitations. This scoping review has several limitations. The search of databases was performed in December 2006. Asynchronous telehealth, with its low-cost technology and potential to decrease reliance on scarce resources for real-time consultation, is still rapidly evolving. Systematic reviews must be updated regularly to ensure that our knowledge of asynchronous telehealth is up to date with new evidence.[110]

The literature search was restricted to English publications. Although there could be reports published in other languages, previous studies have suggested that restricting literature searches to English does not bias systematic reviews of conventional medical interventions.[111]

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. Better 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 10 publications that assessed the use of asynchronous telehealth in pathology and diagnostic radiology were not included in this report. These clinical domains may add information with respect to the benefits of asynchronous telehealth. These publications were eliminated to maintain consistency with other literature on asynchronous telehealth, which generally exclude those medical specialties that traditionally do not involve direct patient care.

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, especially within dermatology, 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 in comparison with face-to-face consultations.

Contributors: 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 (ARJ) conceived the project, developed the initial protocol, assisted in data extraction and participated in all phases of the writing of the report. 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. Donald Husereau reviewed and provided comments on the research protocol and subsequent drafts. All of the authors contributed to the revisions of the report.

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