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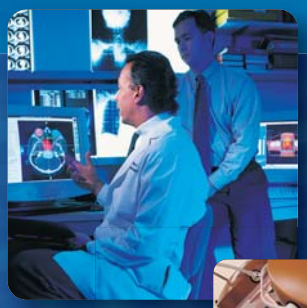

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Publications can be requested from:

CADTH
600-865 Carling Avenue
Ottawa ON Canada K1S 5S8
Tel. (613) 226-2553
Fax. (613) 226-5392
Email: pubs@cadth.ca

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Canadian Agency for Drugs and Technologies in Health

Asynchronous Telehealth: Systematic Review of Analytic Studies and Environmental Scan of Relevant Initiatives

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 FRCP(C)[6]

January 2008

[1] Consultant, Foresight Links Corporation, Toronto, Ontario
[2] Assistant Professor, Department of Community Health Sciences and Medical Director's Office, Aga Khan University, Karachi, Pakistan
[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
[5] Candidate, Department of Health Policy, Management and Evaluation, University of Toronto, Toronto, Ontario
[6] Professor, Chief Innovator and Founder of the Centre for Global eHealth Innovation, University Health Network and University of Toronto, Toronto, Ontario

Reviewers

These individuals kindly provided comments on this report.

External Reviewers

Kendall Ho, MD FRCP(C)
Associate Dean
Division of Continuing Professional Development & Knowledge Translation
University of British Columbia
Vancouver, BC

Edward M. Brown, MD
CEO
The Ontario Telemedicine Network
Toronto, ON

John C. Hogenbirk, MSc
Senior Researcher
Centre for Rural and Northern Health Research
Sudbury, ON

CADTH Peer Review Group Reviewers

Richard E. Scott, PhD BSc 1st Class (Hons)
Associate Professor
University of Calgary
Calgary, AB

Penny Jennett, PhD MA BA CCHRA
Professor
University of Calgary
Calgary, AB

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CADTH takes sole responsibility for the final form and content of this report. The statements and conclusions in this report are those of CADTH and not of its reviewers or Scientific Advisory Panel members.

Authorship

Amol Deshpande 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 conceived the project, developed the initial protocol, assisted in data extraction, and participated in all phases of report writing.

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

Ann McKibbon and Shariq Khoja 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 conflicts of interest.

Dr. Kendall Ho has been a consultant to the BC Ministry of Health Knowledge Management and Technologies Division, which is responsible for provincial eHealth deployment. He has obtained Tri-council research grants to support eHealth and Telehealth research.

REPORT *IN BRIEF*

January 2008

Asynchronous Telehealth: Systematic Review of Analytic Studies and Environmental Scan of Relevant Initiatives

Technology

Asynchronous telehealth refers to the storage of clinically important digital samples and relevant data (e.g., pictures of moles or surgical wounds and radiological images) from any location and forwarding them to a health care professional at a distant site for assessment at a convenient time.

Issue

Asynchronous telehealth could reduce wait times and optimize access to specialized services. There is, however, uncertainty about its effectiveness in health care services.

Methods and Results

This systematic search of studies for any modality of asynchronous telehealth in English in peer-reviewed journals assessing health outcomes, economic outcomes, and health services impact identified 52 original studies, with almost half of them focused on teledermatology. While there was no formal economic analysis, related economic outcomes were extracted from the clinical reviews. Two independent teams of reviewers screened all articles and independently extracted data. The environmental scan, which included Google searches, identified 39 organizations (five in Canada) that are using a combination of real-time and asynchronous services.

Implications for Decision Making

- **Asynchronous telehealth could optimize health care delivery**. Compared with face-to-face consultations, asynchronous telehealth has demonstrated shorter wait times, fewer unnecessary referrals, high levels of patient and provider satisfaction, better diagnostic accuracy, and better access to services in locations that lack health professionals.
- **Uncertainty remains regarding cost-effectiveness and resource use.** Most cost savings were associated with a decrease in patient travel expenses, lost time from work, or caregiver reimbursement. It is unclear whether the use of asynchronous telehealth for triage leads to faster care or improved health outcomes and whether it works beyond small pilot projects.
- **Opportunities for further understanding exist.** By formulating and promoting projects with pragmatic objectives and reasonable outcomes, Canadian policy makers have an opportunity to increase the efficiency of health care services and foster a collaborative framework among existing institutions.

This summary is based on a comprehensive health technology assessment available from CADTH's web site (www.cadth.ca): Deshpande A, Khoja S, Lorca J, McKibbon A, Rizo C, Jadad AR. *Asynchronous Telehealth: Systematic Review of Analytic Studies and Environmental Scan of Relevant Initiatives.*

Canadian Agency for Drugs and Technologies in Health (CADTH)
600-865 Carling Avenue, Ottawa ON Canada K1S 5S8 Tel: 613-226-2553 Fax: 613-226-5392 www.cadth.ca

EXECUTIVE SUMMARY

The Issue

Asynchronous telehealth involves the collection of digital samples (e.g., pictures of moles or surgical wounds, electrocardiograms, spirometry results, radiological images, laboratory test results) at one location and their subsequent transmission to a health professional in another location for review at a different time. Although clinical applications of asynchronous telehealth could alleviate certain burdens of the health care system and facilitate access to services, its utility and position in the system remain poorly defined.

There has been no systematic effort to summarize key messages from the biomedical literature in a manner that policy makers and health care providers would find useful.

Objectives

Our objective was to provide a critical evaluation of the available data on the use of clinical applications of asynchronous telehealth. This report describes two components:

- a systematic review of the peer-reviewed literature on the impact of asynchronous telehealth on health outcomes, process of care, access to health services, and health resources
- an environmental scan to help synthesize the available practices from existing organizations providing asynchronous telehealth services, so that the information is relevant to Canadian policy makers.

This report addressed five questions.

- What evidence exists in the peer-reviewed literature to support the use of asynchronous telehealth to improve health outcomes?
- Does the use of asynchronous telehealth improve access to health delivery services?
- Does asynchronous telehealth affect health care resource use?
- What are patients' and providers' satisfaction levels for services delivered using asynchronous telehealth?
- What organizations and best practices are at the forefront of asynchronous telehealth delivery?

Methods

A search strategy was prepared combing three clusters of terms: one focused on telehealth, the second on asynchronous modalities, and the third on health services delivery. The refined search strategy for MEDLINE appears in Appendix 2. The searches of all databases were completed in mid-December 2006. The searches were run on 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 database search was complemented with a scan of reference lists of eligible reports.

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.

The environmental scan was based on the information available in the articles included in the systematic review, complemented by a scan of 400 hits yielded by an Internet search using the Google search engine.

Results

The systematic review included 52 original studies out of 238 citations identified. The included studies had diverse designs, interventions, and outcomes, precluding meta-analysis. Sixteen studies were judged to be of high quality based on the use of standardized quality assessment tools. Almost half of the studies focused on teledermatology. Most studies showed beneficial effects in terms of diagnostic accuracy, wait times, referral management, and satisfaction with services.

Economic Analysis

Methods: A formal economic analysis was not completed. When available, data pertaining to economic outcomes were extracted from the articles identified in the clinical review.

Results: 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.

Health Services Impact

An environmental scan identified 39 asynchronous clinical telehealth programs worldwide, with five in Canada. The latter seem to be relatively small with a low level of activity. The dearth of standardization across institutions precludes comparison among them.

Conclusions

The overall quality of most of the original studies in asynchronous telehealth is poor. These studies, however, provide 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. The number of organizations identified in the environmental scan highlights the potential of asynchronous telehealth and underscores the need for standardized ways to document their work so that institutions may be compared.

In Canada, where the reduction in wait times for health care has become a priority, asynchronous telehealth could be an option to choose for improving access to specialized services. It is unknown, however, whether the benefits that have been shown in small local studies could be realized after wide-scale implementation.

Policy makers could play a role in helping to shape the future of asynchronous telehealth in Canada. By formulating pragmatic objectives with consistent and reasonable outcomes, policy makers and researchers could promote projects, such as asynchronous telehealth triage services, that could increase the efficiency of the health care system and enrich the body of research.

Canadian policy makers have an opportunity to leverage the experience and resources of the five existing asynchronous telehealth services. Efforts are underway to promote standardization, particularly through the National Telehealth Outcomes Indicators Project (NTOIP), which could

foster collaboration among institutions. These programs could act as living laboratories in which to gain a better understanding, under controlled conditions, of the depth and breadth of services, their associated risks and benefits, their resource implications, and the regulatory framework that would be needed to ensure that asynchronous telehealth contributes to the sustainability of the health care system in Canada.

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1 INTRODUCTION

1.1 Background and Setting in Canada

Canada has relied on access to technology and the need to deliver services to remote and under-served communities as 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. The pool of physicians in Canada is growing slowly, but so too is their average age, which is now approaching 50 years.[1] 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.[2]

One 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. Because of its independence from real-time interactions between patients and health professionals and the low cost of the required infrastructure, asynchronous telehealth could 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.

There are several potential advantages of asynchronous clinical services:

- There could be reduced waiting times, given that asynchronous clinical services do not require the coordination of schedules for patients and providers.
- There could be reduced disparity of access to services, given that real-time interactions are unnecessary. Digital samples could be sent from locations with access to the Internet, regardless of the bandwidth available. Even where there is only a slow Internet connection (e.g., dial-up telephone access), many digital samples could be sent through a telephone line overnight. In addition, asynchronous telehealth benefits from the increasing popularity of cellular telephones with short messaging services (SMS). Using these telephones, text could be exchanged across long distances rapidly and at low cost. This could enable the efficient delivery of normal laboratory test results to patients, eliminating the need for unnecessary clinic visits.
- There could be more efficient use of specialized clinical resources. If asynchronous services are coupled with centralized servers to manage digital samples, work lists could be distributed among specialists who could interpret them at their convenience and from any location. In addition, if cases were prepared in advance, then specialists could achieve a higher turnover of their assessments without a need for face-to-face interaction.
- There could be easier acceptance of telemedicine as a core clinical service. Although real-time telemedicine has been successful in the delivery of services to underserved remote communities, the proportion of patients who benefit from it remains small, because of the dependence of this

approach on the availability of costly infrastructure and on the coordination of schedules for health professionals. Asynchronous telehealth could become an essential component of the health system, because it could be used to increase the efficiency of health services — in remote and urban areas — at comparatively low levels of investment.

So far, clinical applications of asynchronous telehealth have not received the same degree of attention as real-time telehealth.[3] Despite several observational and experimental studies, there is a dearth of systematic efforts to assess its impact through a review of the peer-reviewed literature or through an analysis of best practices by organizations that are promoting this modality.

1.2 Overview of Technology

The point of asynchronous technology is the ability to transmit information without the need for synchronous communication. Technology systems for asynchronous telehealth can be defined as any device capable of capturing a digital sample, possibly through the use of medical peripherals such as spirometers, electrocardiograms, and other appliances; storing it; and then downloading it for transmission to a remote site. The digital samples could be video images from a digital camera or iPod®, an audio file, or simple text files of a patient's history. In the past, the main mode of transfer occurred over electronic digital interfaces (EDI). Larger bandwidth requirements led to a need for the development of integrated services digital network (ISDN) lines and larger cables to transmit data. Now, the Internet provides a means by which large files can be transferred securely, quickly, and inexpensively to almost any location.

2 ISSUE

Asynchronous telehealth involves the collection of digital samples (e.g., pictures of moles or surgical wounds, EKGs, spirometry results, radiological images) at one location and their subsequent transmission to a health professional in a separate location for review. Although asynchronous telehealth could alleviate certain burdens of the health care system and enhance access to services, the impact that clinical asynchronous telehealth could have on various outcomes remains unclear.

There has been no systematic effort to summarize key messages from the biomedical literature in a manner that policy makers and health care providers would find useful.

3 OBJECTIVES

Our objective was to provide a critical evaluation of the available data on the use of asynchronous telehealth for use in primary care. This report describes two components:

- a systematic review of the peer-reviewed literature on the impact of clinical applications of asynchronous telehealth on health outcomes, process of care (e.g., access to health services), health resources, and user satisfaction
- an environmental scan to help synthesize the available practices from existing organizations providing asynchronous telehealth services of relevance to Canadian policy makers.

This report addresses five questions:

- What evidence exists in the peer-review literature to support the use of asynchronous telehealth to improve health outcomes?
- Does the use of asynchronous telehealth improve access to health delivery services?
- Does asynchronous telehealth affect health care resource use?
- What are user satisfaction levels for services delivered using asynchronous telehealth?
- What organizations and best practices are at the forefront of asynchronous telehealth delivery?

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), resulting from a clinical asynchronous intervention. 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 using asynchronous telehealth. Resource use outcomes reported cost-effectiveness data or impact on health care resources such as 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 clinical asynchronous telehealth.

4 CLINICAL REVIEW

4.1 Methods

A protocol for this review was written a priori and followed throughout the review process. There were no deviations from the original protocol (Appendix 1). Article screening and data extraction were performed using TrialStat SRS 4.0 (Ottawa ON), an online application designed to streamline data capture for systematic reviews.

4.1.1 Literature search strategy

A search strategy was prepared combining three clusters of terms: the first focused on telehealth, the second on asynchronous modalities, and the third on health services delivery. The refined search strategy for MEDLINE appears in Appendix 2. All database searches were completed in mid-December 2006. The searches were run on 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 database search was complemented with a scan of reference lists from eligible reports.

4.1.2 Selection criteria and method

a) Selection criteria

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

- It evaluated one or more clinical asynchronous services.
- It involved the capture of digital clinical samples by physicians, community-based nurses, or trained members of the public.

- It focused on the delivery of digital samples for assessment by specialists at separate locations, transferred electronically, for any disease, including heart disease, stroke, cancer, diabetes, and chronic respiratory diseases.
- It included data on health outcomes, process of care, resource utilization, or user satisfaction.
- It was published in an English-language, peer-reviewed journal, from 1995 onward.

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 rather than on clinical or economic outcomes (e.g., different modalities of telehealth or telehealth versus face-to-face consultations).

b) Selection method

Two teams of reviewers [team 1 (AM and CL), team 2 (SK and HD)] independently screened each title and abstract (if available) of a potentially eligible report, categorizing it into one of three groups: "yes" (meets inclusion criteria according to information provided in abstract), "not sure" (obtain the full publication to determine if it meets inclusion criteria), and "no" (does not meet inclusion criteria).

Two other reviewers (AJ and AD) resolved any discrepancies between the two teams by independently reviewing each title and abstract. If disagreements persisted, a final decision was reached by consensus between AJ and AD, or the unresolved discrepancy was labelled as "investigate further" and the full publication was obtained for a more detailed review.

Hard copies of articles labelled as "yes," "not sure," or "investigate further" were obtained from electronic databases, medical journals, or interlibrary loans. Where necessary, selected authors were contacted with a request for a copy of their publication.

4.1.3 Data extraction and abstraction strategy

The same trained reviewers (team 1 and team 2) extracted data independently, using unmasked copies of the reports. Where disagreements existed, the final set was reviewed independently by AJ and AD. Any differences were resolved by consensus.

A standard data extraction form (Appendix 3) was used to collect the data. From each report, data were extracted on:

- 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, or 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).

4.1.4 Strategy for quality assessment

The methodological quality of each study, where relevant, was assessed using validated tools. The Jadad scale was used for randomized controlled trials (RCTs),[4] and the Downs and Black checklist was used for observational studies and controlled clinical trials (CCT)[5] (Appendix 4). The tools used are reliable and validated. Not all scales, however, have a specified cut-off point to distinguish between low quality and high quality studies. The median study quality score was used for this value where no pre-specified score existed.[6] In this review, randomized controlled trials were considered to be high quality if they received a Jadad score greater than 3 points.

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 decided to use 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. A high quality study was defined as one with a score greater than 14 points.

4.1.5 Data analysis methods

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.

A meta-analysis was considered 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.

4.2 Results

4.2.1 Quantity of research available

The literature search yielded 238 publications across all databases. In total, 139 publications were excluded because they did not address issues related to clinical asynchronous telehealth.

In this group, 19 articles were excluded because they focused only on diagnostic concordance issues. One study[7] failed to report any outcome data. A total of 99 potentially eligible publications seemed to have met the inclusion criteria and required selection of the full-text version for further investigation. After review of the full-text version, 37 reports were excluded for various reasons (Table 1). Despite numerous attempts, four articles[8-11] could not be retrieved. From the 33 articles excluded after review of the full-text version, eight[12-19] did not report outcome data, nine[20-28] exclusively assessed concordance between asynchronous telemedicine and another health service delivery modality, three[29,30,108] were systematic reviews, and five[32-36] failed to report original outcome data. Two[37,116] publications were individual case reports, while two[39,40] failed to assess asynchronous technology.

Four publications[41-44] were judged to have been duplicate studies or based on a subset of data from populations previously published in the literature. The original publications on which these articles were based met the eligibility criteria and were included in the final selection.

Table 1: Excluded studies from asynchronous telehealth review

Publication	Reason for Exclusion
Blum *et al.*[7]	Publication did not report any outcome data
Kuo *et al.*[8]	Unable to retrieve full text through multiple sources
Pavlicek *et al.*[9]	Unable to retrieve full text through multiple sources
Mallett[10]	Unable to retrieve full text through multiple sources
Desai *et al.*[11]	Unable to retrieve full text through multiple sources
Chang *et al.*[12]	Publication did not report any outcome data
Dunn *et al.*[13]	Publication did not report any outcome data
Gilbert *et al.*[14]	Publication did not report any outcome data
Krumm *et al.*[15]	Publication did not report any outcome data
Person[16]	Publication did not report any outcome data
Sanchez *et al.*[17]	Publication did not report any outcome data
Sood and Bhatia[18]	Publication did not report any outcome data
Sussmann *et al.*[19]	Publication did not report any outcome data
Burgess *et al.*[20]	Assessed concordance only
Hill *et al.*[21]	Assessed concordance only
Houston *et al.*[22]	Assessed concordance only
Jones *et al.*[23]	Assessed concordance only
Lattimore[24]	Assessed concordance only
Minervini *et al.*[25]	Assessed concordance only
Piccolo *et al.*[26]	Assessed concordance only
Szot *et al.*[27]	Assessed concordance only
Sclafani *et al.*[28]	Assessed concordance only
Currell *et al.*[29]	Systematic review
Whited[30]	Systematic review
Demiris *et al.*[32]	No original data reported
Leong *et al.*[33]	No original data reported
Oakley[34]	No original data reported
Umefjord *et al.*[35]	No original data reported
Whitten[36]	No original data reported
Munir *et al.*[37]	Publication of case report
Duerinckx *et al.*[39]	Did not assess asynchronous technology
Kanzaki *et al.*[40]	Did not assess asynchronous technology
Loane *et al.*[41]	Subset data from Loane *et al.*[84]
Whited *et al.*[42]	Subset data from Whited *et al.*[78]
Whited *et al.*[43]	Subset data from Whited *et al.*[78]
Sibson[44]	Duplicate study population
Williams *et al.*[108]	Systematic review
Weinstock and Kempton[116]	Publication of case report

From the remaining 62 publications, 10 were excluded because they did not address the clinical domains traditionally associated with in-person care (Appendix 5). Six[45-50] involved asynchronous technology in pathology (i.e., telepathology) while four[51-54] addressed radiological applications (i.e., teleradiology). Details of these studies appear in Appendix 6.

The QUOROM flowchart appears in Figure 1.

4.2.2 Study characteristics

Fifty-two studies met the inclusion criteria and were included in this review (Appendix 7). All studies except seven[55-61] were published after 2000.

a) General overview

The primary author was based in the US in 22 publications,[38,55,57,60-78] while 15 publications[31,58,59,79-90] originated from the UK. The remaining studies were distributed across various countries, with Italy producing three[91-93] and the Netherlands producing two.[94,95] Canada was responsible for one publication.[96]

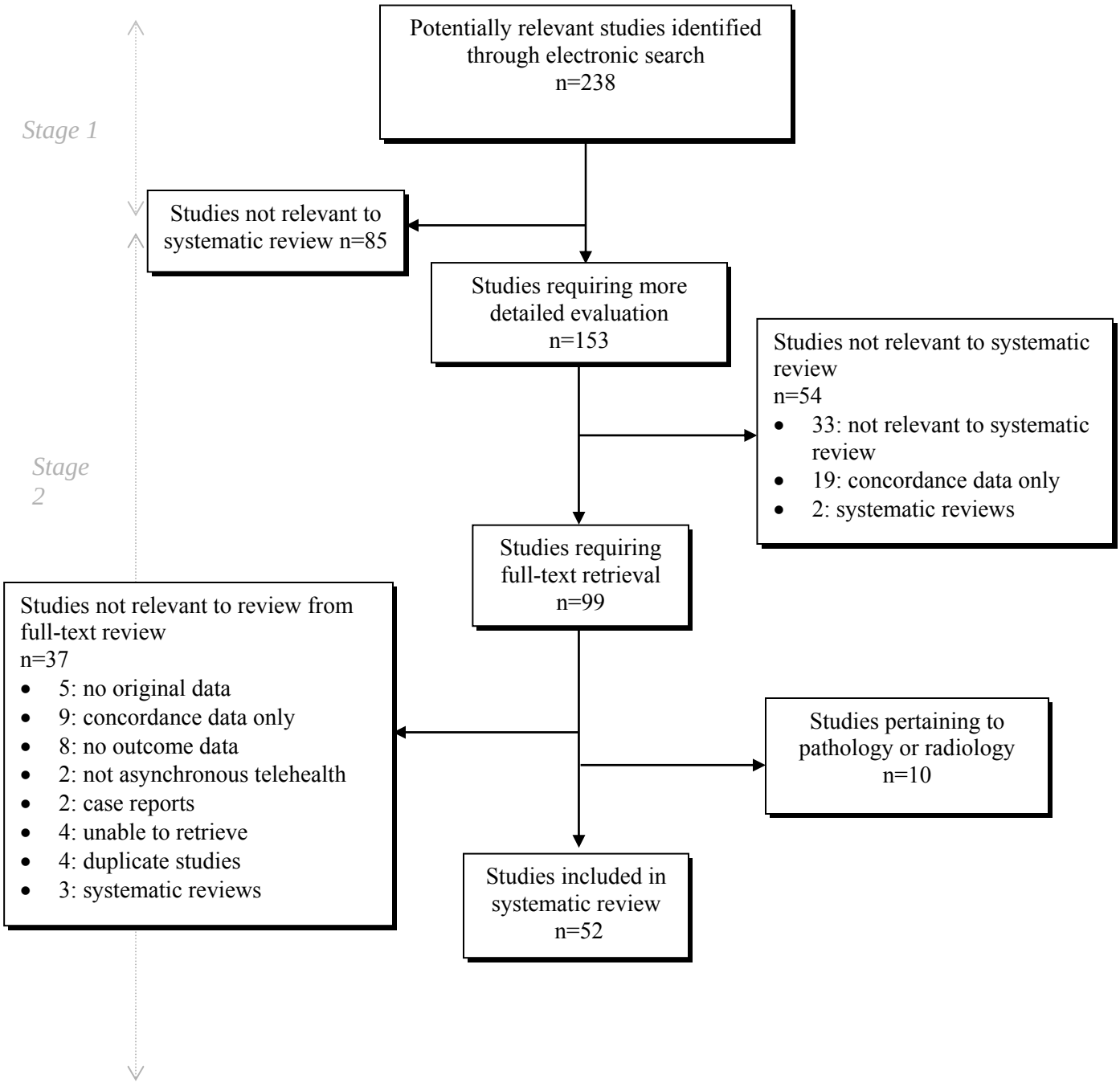
The study designs included three randomized controlled trials (RCTs)[78,84,87] and seven surveys.[31,38,68,81-83,92] Thirty-six publications were designed as case series, while six publications were characterized as cohort studies.

Twenty-eight articles were published in a telemedicine journal. Two-thirds of this group were published in the *Journal of Telemedicine and Telecare*.

A funding source was not documented in 24 publications. Most other studies reported government or academic financial support. No industry sources were reported other than funding of equipment for study purposes.

Dermatology was the most represented clinical domain, involving 24 publications. Nine articles addressed mixed medical conditions,[57,61,63,74,77,90,93,96,97] six addressed musculoskeletal medicine,[62,71,76,79,91,80] four addressed pediatrics,[65,66,72,73] and two addressed ophthalmology.[67,98] Other clinical settings included plastic surgery and the neurological sciences.

Figure 1: Selected reports



b) Quality assessments

One of three RCTs was judged to be of high quality.[87]

Of the remaining 49 studies, 15 received high quality ratings.[38,58,62,63,66,73,79,82,83,89,94,98-101] Quality scores for individual studies appear in Appendix 7.

4.2.3 Data analyses and synthesis

A meta-analysis was considered inappropriate because of the heterogeneity of the studies with respect to design and methodological quality. The results were presented qualitatively.

a) Dermatology (Appendix 8)

Twenty-four or almost half of the publications that met the inclusion criteria focused on the use of asynchronous telehealth in dermatology (i.e., teledermatology). Many publications addressed multiple outcome categories. Health outcomes (mainly diagnostic accuracy) and user satisfaction were the most commonly used categories. Resource use was addressed in 11 publications. Two studies[78, 84] that were included in this review reported resource outcomes in separate publications.

Health outcomes

Eleven publications evaluated the role of health outcomes and asynchronous telehealth in dermatology. Ten of these publications 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.[63] Other reports documented rates of diagnostic accuracy varying between 75% and 88%.[55,89,99] Combining images from telehealth modalities with standard patient histories increased diagnostic accuracy to 90% and 82% ($p<0.001$) for two teledermatologists.[99] There is a high level of agreement with the gold standard (face-to-face) of 0.91 (95% CI: 0.82; 1.00) for clinical teleconsultation and 0.94 (95% CI: 0.88; 1.00) for teledermatoscopy ($p>0.05$).[101] There was variance reported in the ability of asynchronous telehealth to contribute to the development of a management plan. In one study,[102] an appropriate management plan was developed in 84% of the cases, but another study[85] suggested that the use of asynchronous telehealth was successful in 55% of cases while 45% could not be properly assessed. Mallett[86] reported that "advice only" was possible in 8% of cases.

Process of care

The impact of teledermatology on process-of-care outcomes was reported in nine publications. Most studies reported positive outcomes with a reduction in time to consultation. The average time between referral and clinical advice was reported to be 46 hours in one publication.[102] Massone *et al.*[103] reported that of 133 requests analyzed, 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.[78] Klaz *et al.*[100] 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 consultation one third shorter on average than an in-person assessment.[60] Three studies reported the ability to properly prioritize patients to address medical urgency.[59,89,95] White *et al.*[59] 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.[89,95]

b) Multiple clinical domains (Appendix 8)

Nine studies evaluated the role of asynchronous telehealth across a variety of medical conditions. There were no relevant data reported on health outcomes.

Process of care

Articles generally reported that less time was needed to process referrals. Most asynchronous telemedicine cases (67%) had a total turnaround time of less than 72 hours with an average turnaround time for store-and-forward cases of almost 40% faster than for real-time telehealth.[57] 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. [74,90] Actual telemedicine consultations were completed within three days in 14 cases (52%) and within three weeks in 24 cases (89%). Vladymyrszki[97] 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.

c) Orthopedics (Appendix 8)

Six publications reviewed the effect of asynchronous telemedicine in the area of musculoskeletal medicine, with five assessing trauma or injury.[62,76,79,80,91] One[71] focused on post-operative recovery after shoulder surgery.

Health outcomes

One study assessed the validity of asynchronous telemedicine, noting minimal diagnostic disagreement (5% intra-observer and 5.5% inter-observer differences), with face-to-face and similar treatment plans to deliver care.[62] None of the differences identified was regarded as serious (e.g., limb- or life-threatening). Archbold *et al.*[79] reported that 17% of consultations changed the initial management plan as a result of intervention. 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 only study reporting on process of care documented that the average time spent by orthopedic specialists was longer in videoconferencing [21 minutes, standard deviation (SD) 8] than in asynchronous teleconsultations (19 minutes, SD 8). The main limitation was that clinicians' confidence in their diagnosis was generally lower in asynchronous consultations.[91]

d) Pediatrics (Appendix 8)

Four studies addressed pediatrics.[65,66,72,73] All studies reported health outcomes, while three mentioned resource use.

Health outcomes

The use of asynchronous telehealth for pediatric care was associated with positive health outcomes. Two studies, with a combined sample size of 17 patients, assessed the effect of asynchronous telemedicine in pediatric asthma.[66,72] Inhaler technique scores and quality-of-life survey scores improved in the intervention group.[66] The use of asynchronous telehealth was also thought to be helpful in modifying the diagnosis in up to 15% of cases.[65] One study on acute illnesses noted a 63% reduction in absence from school due to illness with the use of telemedicine.[73]

e) Other conditions (Appendix 6)

Two studies focused on asynchronous telehealth for managing ocular conditions. Diagnostic agreement was reported in 12/15 cases that presented with strabismus.[67] 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%).[98] 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).[92] Kokesh *et al.*[69] documented that the use of asynchronous telehealth reduced wait times of four to 15 months "significantly," though specific data were not provided.

5 ECONOMIC ANALYSIS

The purpose of this systematic review was to present data to inform decision makers about the role that asynchronous telemedicine could play in delivering health care to Canadians. A formal economic analysis was not completed for this review. Data regarding cost-effectiveness and impact on resource use were collected from the selected studies, where available.

Eleven publications in teledermatology reported outcomes pertaining to resource use. Two studies[78,84] quantified costs and reported their outcomes in two[41,42] separate publications. Asynchronous telehealth was found to be less expensive than real-time teleconsultation, but its clinical usefulness was limited.[41] Whited *et al.*[42] 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.

Publications in the teledermatology group documented the ability of asynchronous telehealth to decrease the frequency of in-person visits or avoid them. Eminovic[94] reported that 58% of cases required less frequent in-person visits. The avoidance of an in-person visit ranged from 8% to 53%.[59,60,85,86,89,94,95,100] One publication reported that teledermatology resulted in the avoidance of 45% of in-person visits producing a 15% to 20% decline in workload.[60]

In mixed (i.e., multiple) clinical domains, resource use was assessed through the ability to avoid the transfer of patients. Two publications reported an approximately 15% to 23% reduction in transfers.[90,96] One Canadian study[96] 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."[77]

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.[88] The use of teleradiology, in the context of neurosurgical evaluation, reduced the need to transfer a patient by 50%.[56]

Studies in orthopedics reported that the transport of plain films by taxi was avoided in 10 referrals,[79] while in other settings patients avoided transfer or referral.[76,80] Finally, in otolaryngology, 79 of 91 patients saved transport costs, suggesting a savings of US$307.57 per person.[69] This study concluded that for every $1 spent on reimbursement for telehealth, $8 of travel cost could be avoided.

Three studies assessed the role of asynchronous telehealth and the impact of resource use in pediatrics.[65,72,73] All three reported a decrease in health care use. Malone *et al.*[72] 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 *et al.*[73] also reported fewer visits to the emergency room while Callahan *et al.*[65] reported avoidance of air evacuation in 12% of the population by using asynchronous telehealth.

6 HEALTH SERVICES IMPACT

Data regarding patient and provider satisfaction were collected from the previously identified studies, where available.

6.1 User Satisfaction

Patient or provider satisfaction was assessed in 11 publications involving teledermatology and in general was determined to be high. Ninety-three per cent of patients reported that they were happy with teleconsultation.[31] Klaz *et al.*[100] noted an 89% patient satisfaction rate with higher results in rural compared with urban areas. Two studies[82,99] reported that 85% of patients said they would accept teledermatology in the future, with 18% feeling that the conventional asynchronous method was sufficient. In contrast, 38% to 40% agreed with the statement that they would prefer to discuss their skin problem with the dermatologist in person and preferred direct contact.[31,38,82] 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.[82]

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.[55] One early study noted that 81% of general practitioners anticipated problems with implementation, while 15% said that expectations were high.[81] 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.[83] 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[64,77,96] assessing multiple clinical domains commented on patient and provider satisfaction. One study documented that patients were satisfied or very satisfied with the care received.[64] Two others commented on positive acceptance and a general perception of asynchronous telehealth as being beneficial.[77,96]

6.2 Environmental Scan

A systematic approach was used to identify the organizations or initiatives at the forefront of asynchronous telemedicine and organized the information in an evidence-based table.

6.2.1 Search strategy

The search for a comprehensive inventory of asynchronous telehealth organizations included Google searches. The following key words were used: "asynchronous telemedicine" OR "asynchronous telehealth" OR "store-and-forward telemedicine" OR "store-and-forward telehealth" (10,400 hits). The review included the first 200 hits yielded by the Google search.

6.2.2 Selection criteria and methods

a) Selection criteria

To be selected, an organization or initiative had to:

- state as one of its key objectives the promotion and use of store-and-forward telemedicine services to promote access
- provide information about its services through any means (e.g., the Internet, telephone, or face-to-face)
- generate data on the impact of such services.

b) Method

Two reviewers (AD and CR) screened the list of publications identified in the clinical review for full-text retrieval (n=99) and independently extracted the name of the institution. Each paper was scanned to determine the location of the research (e.g., hospital, university). CR removed duplicate institutions (e.g., institutions with the same author were considered to be one entry).

Two Google searches were performed. The first confirmed that the institutions of the clinical review were providers of asynchronous telemedicine services rather than organizations solely involved for the purposes of publication (the name of the institution where authors were affiliated and the words "asynchronous" and "store-and-forward" were used). The second Google search was performed to identify additional institutions providing asynchronous telemedicine services (CR reviewed the first 200 hits). A summary of the selection process is provided in Figure 2.

6.2.3 Data extraction strategy

All the data from organizations meeting the criteria were stored in a Microsoft Excel spreadsheet register. The purpose of this register was to communicate, using a standardized reporting format, the status of data completeness and communication with organizations providing asynchronous telemedicine services.

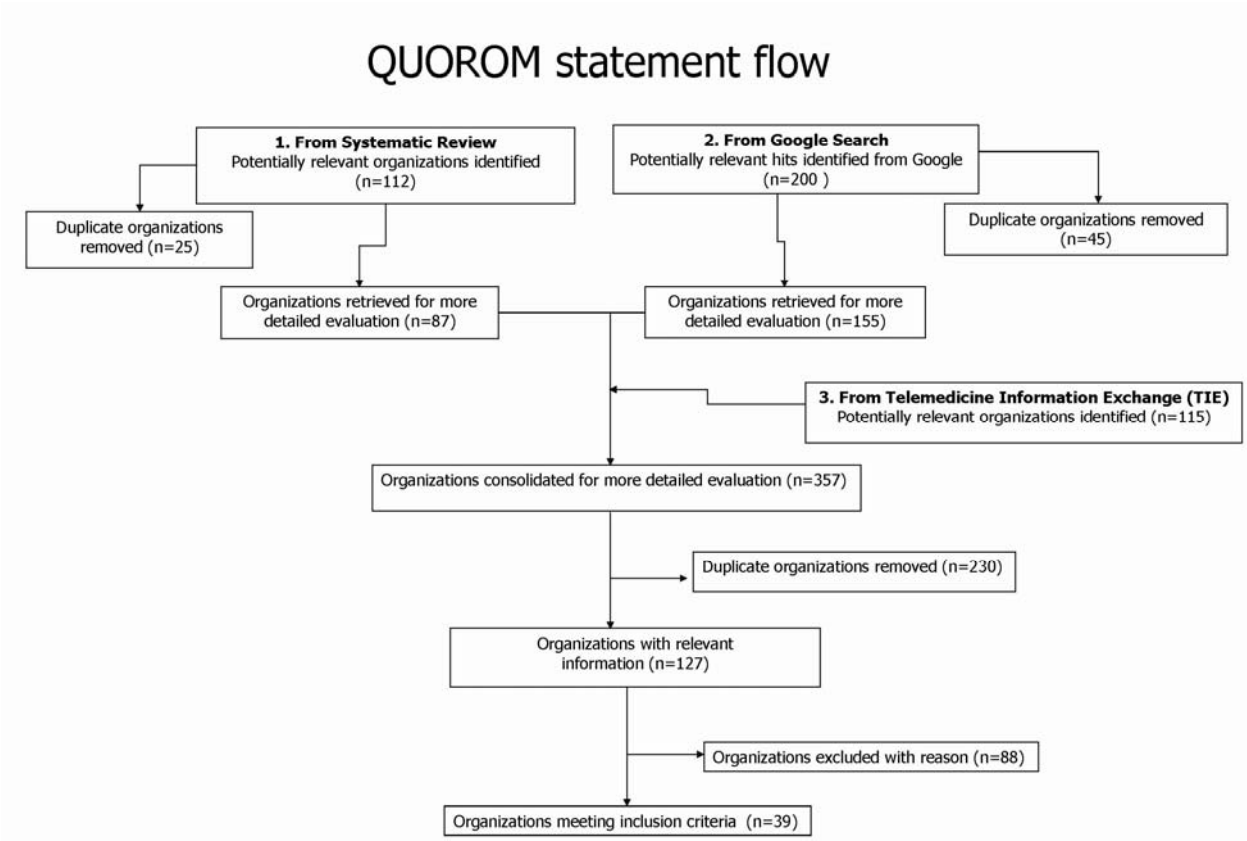
One researcher (CR) collected the following information for each of the identified organizations:

- program name and contact details (e.g., postal address, telephone and fax numbers, URL)
- contact person and organizational leader, wherever possible
- available store-and-forward telemedicine services (e.g., technology, staff, location, clinical scope, date of program inception, number of encounters with patients, and area of coverage)
- publications generated by the organization (author's name, e-mail, and affiliations)
- evidence of impact, as consistent as possible with the evaluation framework developed by the Oregon Evidence-based Practice Center during a systematic review of telehealth interventions on behalf of the US Agency for Healthcare Research and Quality (AHRQ)[104]

Efforts were made to answer the following three questions:

- Does asynchronous telehealth result in comparable diagnostic decisions and recommendations for clinical management?
- Does asynchronous telehealth result in comparable health outcomes?
- Does the availability of asynchronous services improve access?

Figure 2: Asynchronous institutions selected



6.2.4 Quality assurance

We performed additional Google searches that combined the name of the institution where authors were affiliated and the words "store-and-forward" to confirm that these institutions were providers of these services.

The Telemedicine Information Exchange (TIE) (http://tie.telemed.org/default.asp), a comprehensive repository of information about telehealth-related activities, was used to verify the contact information and program coverage details of each eligible organization.

All institutions that were identified were contacted via e-mail. A standard template was sent to the institution to verify the extracted information and to obtain any missing information.

Leaders of institutions or their assistants received a follow up call to confirm receipt of the e-mail message and to obtain additional information.

6.3 Results

Thirty-nine organizations that provide asynchronous telehealth services were identified. Five were located in Canada, 13 in the US, nine in the UK, four in Australia, two in the Netherlands, and one each in Argentina, Austria, Ecuador, Israel, Spain, and Ukraine. Most organizations offered a combination of real-time and asynchronous services (Tables 2 and 3).

The Hersh framework was designed to evaluate telemedicine with respect to three concepts: clinical diagnosis, access to care, and health outcomes. [104]

Of the 39 organizations, one (Tripler Army Medical Center in Hawaii) provided data that could be used to match against all the elements of the evaluation framework. The experience of this organization has been documented in peer-reviewed journals since its inception in 1997. Most of the other organizations failed to provide or did not record these data for program assessment.

6.3.1 Staffing issues

Half of the organizations surveyed seem to have multidisciplinary teams with most clinical specialties providing asynchronous telehealth services.

Teleradiology, teledermatology, and telepathology were the most common services provided followed by psychiatry, internal medicine, rehabilitation, cardiology, pediatrics, obstetrics and gynecology, and neurology.

Establishing the exact number of staff for each program was difficult because of a lack of available data, the nature of the services, and the number of departments that support them. For instance, approximately 700 physicians across more than 80 medical specialties and more than 1,500 health professionals use the Ontario Telehealth Network (OTN) for clinical purposes, but there is little certainty about how personnel are distributed or organized to conduct asynchronous teleconsultations. Every institution surveyed shared this challenge.

6.3.2 Volume of patients and coverage area

With the advances in broadband technology, the issues of coverage area are less important now. Today, asynchronous telehealth services can be used to reach the most remote locations. The US Army has perhaps the broadest coverage of all projects in the world. The asynchronous telehealth initiative in Ontario seems to offer the widest coverage in Canada.

Obtaining meaningful information from the organizations about the volume of patients served by asynchronous telemedicine programs was difficult. Most organizations cited a lack of standards regarding the statistical unit of analysis (number of unique encounters with patients versus number of telemedicine consultations) and deficiencies in data collection. For instance, the OTN previously recorded the number of unique patients assessed as the unit of analysis. Problems in determining the efficiency of some referring sites occurred as patients who needed multiple asynchronous teleconsultations were counted as one unit of analysis. To obtain a better measure of resource utilization, OTN implemented the number of actual encounters undertaken for a given patient as the benchmark for future data gathering.

Table 2: General characteristics of leading asynchronous telehealth programs							
Institution	**Location**	**Date of Inception**	**Technology**	**Comparable Diagnostic Decision**	**Comparable Health Outcomes**	**Comparable access**	**Other Outcomes**
Interconsulta Virtual	Argentina	2001	Digital camera, ophthalmology peripherals, e-mail + VC via ISDN 384 kbps	NA	NA	NA	NA
Centre for Online Health, University of Queensland, Brisbane, Australia	Australia	2000	Digital camera + e-mail + ISDN 128 kpbs	Yes[21]	No	No	Number of referrals 1.05 per month per site, similar to that reported in other primary care studies[102]
Imaging The South	Australia	1998	Digital camera, tele ECG/EKG, exam camera, x-ray scanner, echocardiography equipment	NA	NA	NA	NA
Ear Science Institute Australia	Australia	2002	Otology peripherals, e-mail	NA	NA	NA	NA
TelDermServ — Teledermatologic Network Services for Counselling on Diagnosis of Skin Diseases	Austria	2002	SF + LAN	NA	NA	NA	Feasibility[103]
Alberta Provincial Telehealth Program	Canada (AB)	1998	POTS, 336 kbps, 384 kbps, 512 kbps; fractional T-1, ISDN, government data network	NA	NA	NA	NA
Children's & Women's Health Centre of British Columbia Telehealth Program	Canada (BC)	1997	Digital camera, tele ECG/EKG	NA	NA	NA	NA
The Rehabilitation Centre (The Ottawa Hospital)	Canada (ON)	1996	Mixed	NA	NA	NA	NA

Table 2: General characteristics of leading asynchronous telehealth programs							
Institution	**Location**	**Date of Inception**	**Technology**	**Comparable Diagnostic Decision**	**Comparable Health Outcomes**	**Comparable access**	**Other Outcomes**
River Valley Health – Telehealth	Canada, (NB)	1999	Mixed	NA	NA	NA	NA
Ontario Telemedicine Network	Canada, (ON)	2006	Mixed	NA	NA	NA	NA
Cinterandes Foundation, Cuenca, Ecuador	Ecuador	1997	PC, POTS	Yes[117]	No	Yes[117]	
Israel Defense Forces Medical Corps	Israel	2004	Digital camera + e-mail	Yes[100]	No	Yes[100]	Patients satisfied with access to service and quality[100]
Centro di Ricerca sulla Terapia Neurovegetativa, Dipartimento Scienze Cliniche L. Sacco, University of Milano	Italy (Milan)	NA	POTS, e-mail	NA	NA	NA	Feasibility of shared clinical management [93]
Grupo de Bioingenieria y Telemedicina, ETSI Telecomunicacion, Universidad Politecnica de Madrid, Ciudad Universitaria	Spain (Madrid)	NA	Mixed	Yes[51]	NA	NA	
Department of Medical Informatics, Academic Medical Centre, Amsterdam	The Netherlands	1995	Digital camera + e-mail	No [94]	Yes[94]	Yes[94]	23% of participating patients could have safely been managed without in-person visit to dermatologist
Koninklijke Nederlandsche Maatschappij tot	The Netherlands	NA	Digital camera + e-mail	Yes[95]	NA	Yes[95]	NA

Table 2: General characteristics of leading asynchronous telehealth programs							
Institution	**Location**	**Date of Inception**	**Technology**	**Comparable Diagnostic Decision**	**Comparable Health Outcomes**	**Comparable access**	**Other Outcomes**
bevordering der Geneeskunst — KNMG							
Institute of Telemedicine & Telecare, Royal Hospitals Trust	UK (Belfast)	NA	E-mail	Yes[84]	NA	NA	Referring doctor found neurologist's advice beneficial in 75% of complex cases and in all more straightforward cases;[88] costs showed that real-time teledermatology is clinically feasible but more expensive than conventional care, while store-and-forward teledermatology consultation less expensive but its clinical usefulness limited; sensitivity analysis indicated that real-time teledermatology is as economical as conventional care when fewer artificial assumptions are made about equipment use, costs, and travel distances to hospital[41]
Swinfen Charitable Trust	UK (Gosport)	1998	Digital camera + e-mail	Yes[90]	NA	Yes[90]	NA

The evaluation framework implemented by the team at the Oregon Evidence-based Practice Center[104] during their systematic review of telehealth interventions on behalf of the US Agency for Healthcare Research and Quality (AHRQ) was used to complete this table.

ECG/EKG=electrocardiogram; ISDN=integrated services digital network; LAN=local area network; NA=not applicable; PC=personal computer; POTS=plain old telephone system; SF=store-and-forward; VC=videoconferencing.

Table 3: Asynchronous programs — Contact information and publications					
Institution	**Staff**	**Address and Telephone Number**	**URL**	**Contact Person**	**E-mail Address**
Interconsulta Virtual	Ophthalmologists	Emilio Civit 685, Mendoza, Argentina, M5502GVG. Telephone +54-261-4419999.	http://www.institutozaldivar.com	Giselle Ricur	gricur@institutozaldivar.com
Centre for Online Health, University of Queensland, Brisbane, Australia	Multidisciplinary (dermatology, speech pathology)	Level 3 Foundation Building, Herston Road, Herston, Brisbane, Queensland, Australia, 4029. Telephone +61 7 3346 4702, fax +61 7 3346 4705.	http://www.uq.edu.au/coh/	Anthony Smith, Senior Research Officer	a.smith@pobox.com
Imaging The South	Multidisciplinary	Randell St., Mandurah, Western Australia, Australia, 6210. Telephone +61 0895355444, fax +61 0895357069.	http://www.imagingthesouth.com.au/	Peter Tually, Nuclear Medicine Scientist	p.tually@imagingthesouth.com.au
Ear Science Institute	Hearing specialists	Lions Ear and Hearing Institute, Ground Floor E-Block, SCGH, Nedlands, West Australia, Australia, 6009. Telephone +61 8 9346 3735.	http://www.lehi.com.au	Robert Eikelboom, Senior Research Officer	rob.eikelboom@lehi.com.au
TelDermServ — Teledermatologic Network Services for Counselling on Diagnosis of Skin Diseases	Dermatology	Department of Dermatology, Medical University of Graz, Auenbruggerplatz 8, Graz, Styria, Austria, A-8036 Graz. Telephone +43-316-385-3365, fax +43-316-385-2466.	http://www.telederm.org	H. Peter Soyer, Professor of Dermatology	peter.soyer@uni-graz.at
Alberta Provincial Telehealth Program	Dermatology and radiology (SF)	10303 Jasper Ave., 28th Floor, Edmonton, AB T5J 5C3. Telephone 780-415-2609, fax 780-415-2289.	http://www.albertawellnet.org	Sharlene Stayberg, Provincial Telehealth Director	sharlene.stayberg@gov.ab.ca
Children's & Women's Health Centre of British Columbia Telehealth Program	Multidisciplinary	Vancouver, BC V6H 3N1. Telephone 604-875-3519.	http://www.hc-sc.gc.ca/hcs-sss/pubs/chipp-ppics/2003-bcb-telehealth/index_e.html	Heather Garden, Senior Manager, Telehealth	hgarden@cw.bc.ca

Table 3: Asynchronous programs — Contact information and publications					
Institution	**Staff**	**Address and Telephone Number**	**URL**	**Contact Person**	**E-mail Address**
The Rehabilitation Centre (The Ottawa Hospital)	Multidisciplinary (occupational medicine, pain management, rehabilitation therapy, speech pathology)	505 Smyth Road, Ottawa, ON K1H 8M2. Telephone 613-737-7350.	http://www.ottawahospital.on.ca/sc/rehabcentre/index-e.asp	Edward Lemaire, Research Associate	elemaire@ottawahospital.on.ca
River Valley Health — Telehealth	Multidisciplinary	700 Priestman Street, PO Box 9000, Fredericton, NB E3B 5N5. Telephone 506-447-4135, fax 506-452-5098.	www.rivervalleyhealth.nb.ca/english/Telehealth/Telehomecare_Tool_Kit.pdfhttp://www.rivervalleyhealth.nb.ca/english/progserv/telehealth.htm	Valerie Hagerman, Regional Director, Telehealth	Valerie.Hagerman@rvh.nb.ca
Ontario Telemedicine Network	Multidisciplinary	1090 Don Mills Road, Suite 500, Toronto, ON M3C 3R6. Telephone 416-850-9090, fax 416-850-9091.	http://www.otn.ca/index.html	Ed Brown, MD, Executive Director	ebrown@otn.ca
Cinterandes Foundation, Cuenca, Ecuador	Multidisciplinary	NA	http://www.cinterandes.org/telem.html	E. Rodas	erodas@az.pro.ec

Table 3: Asynchronous programs — Contact information and publications					
Institution	**Staff**	**Address and Telephone Number**	**URL**	**Contact Person**	**E-mail Address**
Israel Defense Forces Medical Corps	Dermatology	D.Z. 02149 - I.D.F- Israel 02149. Telephone +972-3–7379255, fax +972-3–7376300.	http://www.idf.il	Itay Klaz, Head of Medical Quality Section	iklaz@msn.com
Centro di Ricerca sulla Terapia Neurovegetativa, Dipartimento Scienze Cliniche L. Sacco, University of Milano, 20157 Milan, Italy	Multidisciplinary	CTNV Centro Ricerca Terapia Neurovegetativa Via G.B. Grassi 74, 20157 Milano, Italy. Telephone + 02 39042748.	http://www.ctnv.it/	M. Malacarne	segreteria@ctnv.unimi.it
Grupo de Bioingenieria y Telemedicina, ETSI Telecomunicacion, Universidad Politecnica de Madrid, Ciudad Universitaria	Radiology	GBT – Dpto. Tecnología Fotónica – ETSI Telecomunicación –Ciudad Universitaria s/n – 28040, Madrid, Spain.	www.gbt.tfo.upm.es/	E. Gomez	egomez@gbt.tfo.upm.es

Table 3: Asynchronous programs — Contact information and publications					
Institution	**Staff**	**Address and Telephone Number**	**URL**	**Contact Person**	**E-mail Address**
Department of Medical Informatics, Academic Medical Centre, Amsterdam	Dermatology	Academisch Medisch Centrum, Afdeling Klinische Informatiekunde, Meibergdreef 15, 1105 AZ Amsterdam, The Netherlands. Telephone +020-5665269.	http://www.amc.nl/index.cfm?sid=534	N. Eminovic	n.eminovic@amc.uva.nl
Koninklijke Nederlandsche Maatschappij tot bevordering der Geneeskunst — KNMG	Dermatology	Domus Medica, Mercatorlaan 1200, 3528 BL, Utrecht, The Netherlands. Telephone +030 28 23 800.	http://www.knmg.nl	A. Knol	aknol@knmg.nl
Institute of Telemedicine & Telecare, Royal Hospitals Trust	Multidisciplinary (dermatology, neurology)	Belfast Health and Social Care Trust, Trust Headquarters, Nore Villa, Knockbracken Healthcare Park, Saintfield Road, Belfast, BT8 8BH, UK.	http://www.belfasttrust.hscni.net/rvh%20services/Neurosciences.html#P-5_0	V. Patterson and M. Loane	vp498@utvinternet.com and m.loane@mailbox.uq.edu.au or m.loane@qub.ac.uk
Swinfen Charitable Trust	Multidisciplinary	Registered UK Charity No. 1077879, Dene House, Wingham, Canterbury, CT3 1NU, UK.	www.uq.edu.au/swinfen/	D. Vassallo	DJVassallo@aol.com

Table 3: Asynchronous programs — Contact information and publications					
Institution	**Staff**	**Address and Telephone Number**	**URL**	**Contact Person**	**E-mail Address**
Leeds General Infirmary, Dermatology Department	Dermatology	Great George Street, Leeds, West Yorkshire, LS1 3EX, UK.	http://www.leedsteachinghospitals.com/patients/aboutus/hospitals/lgi.php	R. Mahendran	Rajini.Mahendran@mayday.nhs.uk
Centre for Health Informatics and Multiprofessional Education, Royal Free and University College London Medical School	Multidisciplinary (dermatology)	City University, Northampton Square, London, EC1V 0HB, UK. Telephone +44 020 7040 8369.	http://www.soi.city.ac.uk/organisation/chi/research/ehealth.html	Gill Smith, Executive Officer	g.smith-1@city.ac.uk
West Manchester Primary Care Group	Teledermatology nurse	Kath Locke Centre, 123 Moss Lane East, Huln, Manchester, M15 5DD, UK.	http://www.manchesterhealth.co.uk/home/index.html	T. Williams	tracy.l.williams@man.ac.uk
Department of Dermatology, Peterborough District Hospital, Peterborough, UK	Dermatology	Peterborough District Hospital, Thorpe Road, Peterborough, PE3 6DA, UK. Telephone +44 01733-874-000.	http://www.tis.bl.uk/jsp/search/organisation.jsp?organisation=387	Dick Mallett	dick.mallett@pbh-tr.nhs.uk
Centre for Radiography Education, University of Portsmouth, UK	Radiology	St George's Building, 141 High Street, Portsmouth, UK, PO1 2HY. Telephone: +44 (0) 23 9284 5389.	http://www.port.ac.uk/departments/academic/radiography/	P. Hussain	budgiehussain@port.ac.uk

Table 3: Asynchronous programs — Contact information and publications					
Institution	**Staff**	**Address and Telephone Number**	**URL**	**Contact Person**	**E-mail Address**
Academic Palliative Medicine Unit, University of Sheffield, Sheffield, UK	Dermatology	The University of Sheffield, Western Bank, Sheffield, S10 2TN, UK.	http://www.shef.ac.uk/medicine/research/sections/oncology/spcsg/ (pages are under re-development)	K. Collins	k.collins@sheffield.ac.uk
GP Services, Royal Cornwall Hospital, Treliske, Truro, UK	Dermatology	RCH Treliske, Royal Cornwall Hospitals Trust, Gloweth, Truro, Cornwall, TR1 3LJ. Telephone +44 (0) 1872-250-000.	http://www.tis.bl.uk/jsp/search/organisation.jsp?organisation=15	White Harold	NA
Department of Informatics and Telemedicine, Donetsk R&D Institute of Traumatology and Orthopedics	Multidisciplinary (orthopedic surgery)	ul. Levitskogo, d. 21, k.1, 83048 Donetsk, Ukraine.	www.telemed.org.ua/wwwtm_eng/TM/ukrtm.html	A. V. Vladzymyrsky	avv@telemed.org.ua
Alaska Federal Health Care Access Network (AFHCAN)	Multidisciplinary	4000 Ambassador Drive, Division of Information Technology, Anchorage, AK, 99508, USA. Telephone 907-729-2262.	http://www.afhcan.org	A. Stewart Ferguson, Director of AFHCAN	sferguson@afhcan.org

Table 3: Asynchronous programs — Contact information and publications					
Institution	**Staff**	**Address and Telephone Number**	**URL**	**Contact Person**	**E-mail Address**
Arizona Telemedicine Program	Multidisciplinary	1501 N. Campbell Avenue, P.O. Box 245105, Tucson, AZ, 85724-5105, USA. Telephone 520-626-2493.	http://www.telemedicine.arizona.edu	Sandy Beinar, Associate Director, Administration	beinars@u.arizona.edu
Second Opinion	Multidisciplinary	3830 Del Amo Blvd., Suite 101, CA, 90503, USA.	http://www.2opinion.com/medindex.htm	Timothy Kaufma, CEO and Charlene Apel, President	corp@2opinion.com
Stanford University, Department of Dermatology	Dermatology	300 Pasteur Drive HF006, Stanford, CA, 94305, USA. Telephone 650-723-4771.	http://tie.telemed.org/programs_t2/showprogram_t2.asp?item=2669	Purna Prasad, Assistant Director, Advanced Technology	purna.prasad@medcenter.stanford.edu
Centre for Telehealth and Healthcare Communications	Multidisciplinary	P.O. Box 100164, Gainesville, FL, 32610-0164, USA. Telephone 352-273-5216.	http://telehealth.phhp.ufl.edu/Services.htm	Jeff Loomis, Associate Director	jloomis@ufl.edu
Tripler Army Medical Center	Multidisciplinary	1 Jarret White Road, 2D236 TAMC, Honolulu, HI, 96859-5000, USA.	http://www.tamc.amedd.army.mil/	Donald Person; Charles Callahan; Debora Chan	donald.person@haw.tamc.amedd.army.mil charles.callahan@us.army.mil; debora.chan@amedd.army.mil

Table 3: Asynchronous programs — Contact information and publications					
Institution	**Staff**	**Address and Telephone Number**	**URL**	**Contact Person**	**E-mail Address**
Partners In Health Telemedicine Network (PHTN)	Multidisciplinary	55 Fruit Street, VBK 9, Boston, MA, 02114, USA. Telephone 617-724-9295 or 888-456-5003.	http://telemedicine.partners.org/telemedicine/	H. Brandling-Bennet	NA
UMass Memorial Medical Health Care Center	Multidisciplinary	Hahnemann Campus, 281 Lincoln Street, Worcester, MA, 01605, USA.	http://www.umassmemorial.org/ummhc/about/index.cfm	S. A. Pap	spapmd@mindspring.com
TATRC/MRMC or Telemedicine and Advanced Technology Research Centre / United States Armed Medical Research and Material Command	Multidisciplinary	MCMR-ZB-T (TATRC), Bldg. 1054 Patchel Street, Fort Detrick, MD, 21702-5012, USA. Telephone 301-619-7927.	http://www.tatrc.org/	Lori DeBernardis, Director of Marketing and Public Affairs	debernardis@tatrc.org
Minnesota Telehealth Network	Multidisciplinary (dermatology)	Fairview-University Medical Center, University campus, 500 Harvard St., Minneapolis, MN, 55455, USA. Telephone 218-631-7481.	http://www.fairview-university.fairview.org/community/Telemedicine/index.asp	Maureen Ideker, Co-director for rural sites	maureen.ideker@tricountyhospital.org

Table 3: Asynchronous programs — Contact information and publications					
Institution	**Staff**	**Address and Telephone Number**	**URL**	**Contact Person**	**E-mail Address**
Duke University Medical Center, DUMC, Department of Radiology	Multidisciplinary	Duke University Medical Center, DUMC, Department of Radiology, Box 3808, Durham, NC, 27710, USA. Telephone 919-684-6398	http://telemedicine.mc.duke.edu/index.html	Joseph Kisslo, MD, Director, Duke TeleMedicine	joseph.kisslo@duke.edu
Institute for Clinical and Epidemiologic Research, Department of Veterans Affairs Medical Center, Durham, NC	Dermatology	Institute for Clinical and Epidemiologic Research, Department of Veterans Affairs Medical Center, Durham, NC, 27705, USA.	http://www.va.gov/midatlantic/facilities/durham.asp	J. D. Whited	white046@mc.duke.edu
Centre for Future Health, University of Rochester Medical Center, Rochester, New York	Pediatrics	University of Rochester Medical Center, Department of Pediatrics, Rochester, NY, 14642, USA.	http://www.futurehealth.rochester.edu/team/bios/Kenneth_Connochie.html	K. M. McConnochie	ken_mcconnochie@urmc.rochester.edu

Another problem cited by most organizations is the lack of data collection specific to asynchronous telemedicine, partly because all real-time and asynchronous teleconsultations are aggregated in a common field. For example, the OTN has logged more than 23,000 tele-consultations in 330 locations, but the exact number of real-time and asynchronous tele-consultations performed is unknown. The Réseau Universitaire Intégré de Santé in Laval, Quebec, made the distinction and recorded 2,188 asynchronous teleconsultations versus 102 real-time consultations in 2005.[105] The Quebec telemedicine network, however, did not meet the environmental scan selection criteria. Other telehealth networks are trying to overcome similar data collection challenges and are implementing procedures to record volumes of patients consistently.

7 DISCUSSION

7.1 Summary of Results

A total of 52 publications were identified for this review. Almost half of the publications focused on teledermatology. Similar to other systematic reviews on telehealth, the original literature in general was judged to be of low quality.[104,106,107]

Beyond diagnostic accuracy and concordance, most publications failed to 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 several publications assessing asynchronous telehealth for 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 telemedicine in the management of chronic conditions.[104]

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%.[100] 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 cost-effectiveness of telehealth has been assessed in the literature.[106] The results of this review reveal studies that use poor methods. This is consistent with findings from previous reviews. Most of the evidence for cost savings is implied through indirect effects on a reduction in resource use. In teledermatology, there was variation in the ability to avoid in-person assessment. Most of the cost savings in these situations were likely obtained 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. As a result, studies seeking to prove cost-effectiveness in more urban areas may not prove to be compelling. In contrast, some studies reported a decreased frequency or avoidance of transfer of patients. This was most notable for the triage of surgical cases in orthopedics and neurosurgery. In these situations, it is possible to avoid the mobilization of a team of health professionals (e.g., ambulance attendant, nurse, and physician).

The quality of literature on patient satisfaction, as in other aspects of telehealth, was considered to be poor.[108] Consistent with previous publications, however, satisfaction levels were generally above 80% for teledermatology, although some studies reported a preference for in-person consultation.[31,82] The satisfaction ratings seemed to be influenced by wait times for obtaining traditional in-person care. Providers' acceptance was mixed with consultants who were 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, clinicians reported a positive acceptance of the use of asynchronous telehealth.

As shown in this review, although the evidence is weak, there are trends that support the use of asynchronous telehealth as a supplement to health services rather than as a replacement. An impediment to success may lie in the expectation that asynchronous technology should function equally well across all clinical domains and in all outcome categories. An alternative approach is to consider asynchronous telehealth as an incremental sustaining innovation[109] — that is, a technology that could provide a small improvement in existing health services by addressing specific quality domains. For example, the use of teledermatology to triage patients may not improve health outcomes, but there is evidence to suggest that it could facilitate the prioritization of patients referred by primary care providers for in-person assessments. This could allow those who need service most urgently (e.g., those with skin cancer) to obtain more rapid care. In surgery, this technology could assist health providers in determining whether patients should be transferred to larger secondary or tertiary care centres, thus potentially avoiding the transfer of patients, and could also improve post-operative home-based care.

7.2 Study Limitations

This systematic review had several limitations. The search of databases was performed in December 2006. Asynchronous telehealth, with its low cost technology and potential to decrease an over-reliance on the scarce availability of its real-time counterpart, is still evolving. Systematic reviews must be updated regularly to ensure that the knowledge is kept up-to-date based on new evidence.[110]

The search strategy focused on the clinical applications of asynchronous telehealth but may not have identified all economic evaluations of remote home-based monitoring. The best evidence for improved health outcomes seems to originate from this body of literature. A review focusing on this area may generate more robust results to support the use of asynchronous telehealth in this domain.

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 exclusion of unpublished studies in this systematic review could introduce bias.[112-114] The pursuit of grey literature, although important, was beyond the resources available for this review.

Ten publications that were identified in pathology and radiology were not included in the report of this review. 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.

7.3 Knowledge Gaps

The quality of research in telehealth continues to be problematic. Most publications fail to meet basic methodological principles or they describe results from small samples, which are usually part of feasibility studies or pilot projects. There is a need for policy makers, researchers, and clinicians to collaborate and explore the benefits of asynchronous telehealth through larger and more rigorous studies.

Canada can lead the research effort through its strength in existing telehealth efforts and infrastructure. The National Telehealth Outcomes Indicators Project (NTOIP)[115] is an example of Canada's potential to collaborate nationally on initiatives that would allow standardization to evolve in telehealth evaluation. Its development of standardized policies for assessing outcomes, outlining a minimum of 12 outcome indicators across four domains (quality, access, acceptability, and cost), offers a foundation on which to support efforts to strengthen the quality of future research.

By considering defined objectives based on existing trends and addressing current health care issues, policy makers could help lead and foster the pragmatic use of asynchronous technology in the health system.

8 CONCLUSIONS

The overall quality of most of the original studies in asynchronous telehealth is poor. These studies, however, provide 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. The number of organizations identified in the environmental scan highlights the potential of asynchronous telehealth, but also underscores the need for standardized ways to document their work and enable comparisons across institutions.

In Canada, where the reduction in wait times for health care has become a national priority, asynchronous telehealth could be considered as an option to improve access to specialized services. It is unknown, however, whether the benefits that have been shown in small local studies could be realized after wide-scale implementation.

Policy makers could play a role in helping shape the future of asynchronous telehealth in Canada. By formulating pragmatic objectives with consistent and reasonable outcomes, policy makers and researchers could promote projects, such as asynchronous telehealth triage services, that could not only increase the efficiency of the health care system, but also enrich the body of research.

Canadian policy makers have an opportunity to leverage the experience and resources of the five existing asynchronous telehealth services. Efforts are underway to promote standardization, particularly through the National Telehealth Outcomes Indicators Project (NTOIP), which could foster a collaborative framework among institutions. These programs could act as living laboratories in which to gain a better understanding, under controlled conditions, of the depth and breadth of different services, their associated risks and benefits, their resource implications, and the regulatory framework that would be needed to ensure that asynchronous telehealth contributes to the sustainability of the health care system.

9 REFERENCES

1. Kondro W. Trends in physician supply. *CMAJ*. Nov 21 2006;175(11):1362.
2. *Physician Workforce in Canada: Literature Review and Gap Analysis. Final Report*: Canadian Labour and Business Centre for Task Force Two: A Physician Human Resource Strategy for Canada; January 2003.
3. Jaatinen PT, Forsstrom J, Loula P. Teleconsultations: who uses them and how? *J Telemed Telecare.* 2002;8(6):319-324.
4. Jadad AR, Moore RA, Carroll D, et al. Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Control Clin Trials.* Feb 1996;17(1):1-12.
5. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health.* Jun 1998;52(6):377-384.
6. Brouwers MC, Johnston ME, Charette ML, Hanna SE, Jadad AR, Browman GP. Evaluating the role of quality assessment of primary studies in systematic reviews of cancer practice guidelines. *BMC Med Res Methodol.* Feb 16 2005;5(1):8.
7. Blum A, Hofmann-Wellenhof R, Luedtke H, et al. Value of the clinical history for different users of dermoscopy compared with results of digital image analysis. *J Eur Acad Dermatol Venereol.* Nov 2004;18(6):665-669.
8. Kuo RL, Aslan P, Dinlenc CZ, et al. Secure transmission of urologic images and records over the Internet. *J Endourol.* Apr 1999;13(3):141-146.
9. Pavlicek W, Zavalkovskiy B, Eversman WG. Performance and function of a high-speed multiple star topology image management system at Mayo Clinic Scottsdale. *J Digit Imaging.* May 1999;12(2 Suppl 1):168-174.
10. Mallett RB. Teledermatology in practice: the Peterborough experience. *Brit J Healthc Comp.* 2000;17(5):14-17.
11. Desai S, Patil R, Chinoy R, et al. Experience with telepathology at a tertiary cancer centre and a rural cancer hospital. *Natl Med J India.* Jan-Feb 2004;17(1):17-19.
12. Chang SW, Plotkin DR, Mulligan R, Polido JC, Mah JK, Meara JG. Teledentistry in rural California: a USC initiative. *J Calif Dent Assoc.* Aug 2003;31(8):601-608.
13. Dunn BE, Choi H, Lamagro UA, Recla DL. Combined robotic and non robotic telepathology as an integral service component of a geographically dispersed laboratory network. *Human Pathology.* 2001;32(12):1300-1303.
14. Gilbert BK, Mitchell MP, Bengali AR, Khandheria BK. NASA/DARPA advanced communications technology satellite project for evaluation of telemedicine outreach using next-generation communications satellite technology: Mayo Foundation participation. *Mayo Clin Proc.* Aug 1999;74(8):753-757.
15. Krumm M, Ribera J, Schmiedge G. Using a telehealth medium for objective hearing testing: implications for supporting rural universal newborn hearing screeining program. *Seminars in Hearing.* 2005;26(1):3-12.
16. Person DA. The Pacific Island Health Care Project: easing the cancer burden in the United States associated Pacific Islands. *Pac Health Dialog.* Sep 2004;11(2):243-247.
17. Sanchez Dils E, Lefebvre C, Abeyta K. Teledentistry in the United States: a new horizon of dental care. *Int J Dent Hyg.* Nov 2004;2(4):161-164.
18. Sood SP, Bhatia JS. Development of telemedicine technology in India: "Sanjeevani"--an integrated telemedicine application. *J Postgrad Med.* Oct-Dec 2005;51(4):308-311.
19. Sussmann H, Griebel H, Allescher HD, Egger K, Sandschin W, Horsch A. The teleconsultation service ENDOTEL. Implementation and first experiences. *Stud Health Technol Inform.* 2000;77:1117-1121.

20. Burgess LP, Holtel MR, Syms MJ, Birkmire-Peters DP, Peters LJ, Mashima PA. Overview of telemedicine applications for otolaryngology. *Laryngoscope.* Sep 1999;109(9):1433-1437.

21. Hill AJ, Theodoros DG, Russell TG, Cahill LM, Ward EC, Clark KM. An Internet-based telerehabilitation system for the assessment of motor speech disorders: a pilot study. *Am J Speech Lang Pathol.* Feb 2006;15(1):45-56.

22. Houston MS, Myers JD, Levens SP, et al. Clinical consultations using store-and-forward telemedicine technology. *Mayo Clin Proc.* Aug 1999;74(8):764-769.

23. Jones SM, Milroy C, Pickford MA. Telemedicine in acute plastic surgical trauma and burns. *Ann R Coll Surg Engl.* Jul 2004;86(4):239-242.

24. Lattimore MR, Jr. A store-forward ophthalmic telemedicine case report from deployed U. S. Army forces in Kuwait. *Telemed J.* Fall 1999;5(3):309-313.

25. Minervini MI, Yagi Y, Marino IR, et al. Development and experience with an integrated system for transplantation telepathology. *Hum Pathol.* Dec 2001;32(12):1334-1343.

26. Piccolo D, Soyer HP, Burgdorf W, et al. Concordance between telepathologic diagnosis and conventional histopathologic diagnosis: a multiobserver store-and-forward study on 20 skin specimens. *Arch Dermatol.* Jan 2002;138(1):53-58.

27. Szot A, Jacobson FL, Munn S, et al. Diagnostic accuracy of chest X-rays acquired using a digital camera for low-cost teleradiology. *Int J Med Inform.* Feb 2004;73(1):65-73.

28. Sclafani AP, Heneghan C, Ginsburg J, Sabini P, Stern J, Dolitsky JN. Teleconsultation in otolaryngology: live versus store and forward consultations. *Otolaryngol Head Neck Surg.* Jan 1999;120(1):62-72.

29. Currell R, Urquhart C, Wainwright P, Lewis R. Telemedicine versus face to face patient care: effects on professional practice and health care outcomes. *Cochrane Database Syst Rev.* 2000(2):CD002098.

30. Whited JD. Teledermatology research review. *Int J Dermatol.* Mar 2006;45(3):220-229.

31. Williams T, May C, Esmail A, et al. Patient satisfaction with store-and-forward teledermatology. *J Telemed Telecare.* 2001;7 Suppl 1:45-46.

32. Demiris G, Speedie SM, Hicks LL. Assessment of patients' acceptance of and satisfaction with teledermatology. *J Med Syst.* Dec 2004;28(6):575-579.

33. Leong FJ. Practical applications of Internet resources for cost-effective telepathology practice. *Pathology.* Nov 2001;33(4):498-503.

34. Oakley AM. Teledermatology in New Zealand. *J Cutan Med Surg.* Mar-Apr 2001;5(2):111-116.

35. Umefjord G, Malker H, Olofsson N, Hensjo LO, Petersson G. Primary care physicians' experiences of carrying out consultations on the internet. *Inform Prim Care.* 2004;12(2):85-90.

36. Whitten PS. Teledermatology delivery modalities: real time versus store and forward. *Curr Probl Dermatol.* 2003;32:24-31.

37. Munir JA, Soh EK, Hoffmann TN, Stewart JP. A novel approach to tele-echocardiography across the Pacific. *Hawaii Med J.* Oct 2004;63(10):310-313.

38. Weinstock MA, Nguyen FQ, Risica PM. Patient and referring provider satisfaction with teledermatology. *J Am Acad Dermatol.* Jul 2002;47(1):68-72.

39. Duerinckx AJ, Hayrapetian A, Melany M, et al. Real-time sonographic video transfer using asynchronous transfer mode technology. *AJR Am J Roentgenol.* May 1997;168(5):1353-1355.

40. Kanzaki H, Makimoto K, Takemura T, Ashida N. Development of web-based qualitative and quantitative data collection systems: study on daily symptoms and coping strategies among Japanese rheumatoid arthritis patients. *Nurs Health Sci.* Sep 2004;6(3):229-236.

41. Loane MA, Bloomer SE, Corbett R, et al. A comparison of real-time and store-and-forward teledermatology: a cost-benefit study. *Br J Dermatol.* Dec 2000;143(6):1241-1247.

42. Whited JD, Datta S, Hall RP, et al. An economic analysis of a store and forward teledermatology consult system. *Telemed J E Health.* Winter 2003;9(4):351-360.

43. Whited JD, Hall RP, Foy ME, et al. Patient and clinician satisfaction with a store-and-forward teledermatology consult system. *Telemed J E Health.* Winter 2004;10(4):422-431.

44. Sibson L. The Plymouth experience: skin cancer screening using a store and forward telemedicine system. *ITIN.* 2000;12(1):6-9.

45. Desai S, Patil R, Kothari A, et al. Static telepathology consultation service between Tata Memorial Centre, Mumbai and Nargis Dutt Memorial Charitable Hospital, Barshi, Solapur, Maharashtra: an analysis of the first 100 cases. *Indian J Pathol Microbiol.* Oct 2004;47(4):480-485.

46. Dunn BE, Choi H, Almagro UA, Recla DL, Krupinski EA, Weinstein RS. Routine surgical telepathology in the Department of Veterans Affairs: experience-related improvements in pathologist performance in 2200 cases. *Telemed J.* Winter 1999;5(4):323-337.

47. Dunn BE, Almagro UA, Choi H, Recla DL, Weinstein RS. Use of telepathology for routine surgical pathology review in a test bed in the Department of Veterans Affairs. *Telemed J.* Spring 1997;3(1):1-10.

48. Lanschuetzer CM, Pohla-Gubo G, Schafleitner B, et al. Telepathology using immunofluorescence/immunoperoxidase microscopy. *J Telemed Telecare.* 2004;10(1):39-43.

49. Marcelo A, Fontelo P, Farolan M, Cualing H. Effect of image compression on telepathology. A randomized clinical trial. *Arch Pathol Lab Med.* Nov 2000;124(11):1653-1656.

50. Settakorn J, Kuakpaetoon T, Leong FJ, Thamprasert K, Ichijima K. Store-and-forward diagnostic telepathology of small biopsies by e-mail attachment: a feasibility pilot study with a view for future application in Thailand diagnostic pathology services. *Telemed J E Health.* Fall 2002;8(3):333-341.

51. Gomez EJ, Caballero PJ, Malpica N, del Pozo F. Optimisation and evaluation of an asynchronous transfer mode teleradiology co-operative system: the experience of the EMERALD and the BONAPARTE projects. *Comput Methods Programs Biomed.* Mar 2001;64(3):201-214.

52. Hussain P, Melville D, Mannings R, Curry D, Kay D, Ford P. Evaluation of a training and diagnostic ultrasound service for general practitioners using narrowband ISDN. *J Telemed Telecare.* 1999;5 Suppl 1:S95-99.

53. Johnson MA, Davis P, McEwan AJ, et al. Preliminary findings from a teleultrasound study in Alberta. *Telemed J.* Fall 1998;4(3):267-276.

54. Lewis C. A tele-ultrasound needs analysis in Queensland. *J Telemed Telecare.* 2005;11 Suppl 2:S61-64.

55. Zelickson BD, Homan L. Teledermatology in the nursing home. *Arch Dermatol.* Feb 1997;133(2):171-174.

56. Heautot JF, Gibaud B, Catroux B, et al. Influence of the teleradiology technology (N-ISDN and ATM) on the inter-hospital management of neurosurgical patients. *Med Inform Internet Med.* Apr-Jun 1999;24(2):121-134.

57. Krupinski E, Webster P, Dolliver M, Weinstein RS, Lopez AM. Efficiency analysis of a multi-specialty telemedicine service. *Telemed J.* Fall 1999;5(3):265-271.

58. Sibson L, Dunn R, Evans J, Jones R, Hayward M, Wallace S. The virtual mole clinic: preliminary results from the Plymouth skin cancer screening study using telemedicine. *Med Inform Internet Med.* Jul-Sep 1999;24(3):189-199.

59. White H, Gould D, Mills W, Brendish L. The Cornwall dermatology electronic referral and image-transfer project. *J Telemed Telecare.* 1999;5 Suppl 1:S85-86.

60. Pak HS, Welch M, Poropatich R. Web-based teledermatology consult system: preliminary results from the first 100 cases. *Stud Health Technol Inform.* 1999;64:179-184.

61. Gomez E, Poropatich R, Karinch MA, Zajtchuk J. Tertiary telemedicine support during global military humanitarian missions. *Telemed J.* Fall 1996;2(3):201-210.

62. Abboud JA, Bozentka DJ, Beredjiklian PK. Telemedicine consultation for patients with upper extremity disorders is reliable. *Clin Orthop Relat Res.* Jun 2005(435):250-257.

63. Barnard CM, Goldyne ME. Evaluation of an asynchronous teleconsultation system for diagnosis of skin cancer and other skin diseases. *Telemed J E Health.* Winter 2000;6(4):379-384.

64. Brandling-Bennett HA, Kedar I, Pallin DJ, Jacques G, Gumley GJ, Kvedar JC. Delivering health care in rural Cambodia via store-and-forward telemedicine: a pilot study. *Telemed J E Health.* Feb 2005;11(1):56-62.

65. Callahan CW, Malone F, Estroff D, Person DA. Effectiveness of an Internet-based store-and-forward telemedicine system for pediatric subspecialty consultation. *Arch Pediatr Adolesc Med.* Apr 2005;159(4):389-393.

66. Chan DS, Callahan CW, Sheets SJ, Moreno CN, Malone FJ. An Internet-based store-and-forward video home telehealth system for improving asthma outcomes in children. *Am J Health Syst Pharm.* Oct 1 2003;60(19):1976-1981.

67. Helveston EM, Orge FH, Naranjo R, Hernandez L. Telemedicine: Strabismus e-consultation. *J AAPOS.* Oct 2001;5(5):291-296.

68. Hersh W, Miller R, Olson D, Sacherek L, Cross P. Professional's Information Link (PiL): a web-based asynchronous consultation service. *Proc AMIA Symp.* 2002:325-329.

69. Kokesh J, Ferguson AS, Patricoski C. Telehealth in Alaska: delivery of health care services from a specialist's perspective. *Int J Circumpolar Health.* Dec 2004;63(4):387-400.

70. Krupinski EA, Engstrom M, Barker G, Levine N, Weinstein RS. The challenges of following patients and assessing outcomes in teledermatology. *J Telemed Telecare.* 2004;10(1):21-24.

71. Lau C, Churchill RS, Kim J, Matsen FA, 3rd, Kim Y. Asynchronous web-based patient-centered home telemedicine system. *IEEE Trans Biomed Eng.* Dec 2002;49(12):1452-1462.

72. Malone F, Callahan CW, Chan DS, Sheets S, Person DA. Caring for children with asthma through teleconsultation: "ECHO-Pac, The Electronic Children's Hospital of the Pacific". *Telemed J E Health.* Summer 2004;10(2):138-146.

73. McConnochie KM, Wood NE, Kitzman HJ, Herendeen NE, Roy J, Roghmann KJ. Telemedicine reduces absence resulting from illness in urban child care: evaluation of an innovation. *Pediatrics.* May 2005;115(5):1273-1282.

74. Mukundan S, Jr., Vydareny K, Vassallo DJ, Irving S, Ogaoga D. Trial telemedicine system for supporting medical students on elective in the developing world. *Acad Radiol.* Jul 2003;10(7):794-797.

75. Pap SA, Lach E, Upton J. Telemedicine in plastic surgery: E-consult the attending surgeon. *Plast Reconstr Surg.* Aug 2002;110(2):452-456.

76. Person DA, Hedson JS, Gunawardane KJ. Telemedicine success in the United States Associated Pacific Islands (USAPI): two illustrative cases. *Telemed J E Health.* Spring 2003;9(1):95-101.

77. Person DA. Pacific Island Health Care Project: early experiences with a Web-based consultation and referral network. *Pac Health Dialog.* Sep 2000;7(2):29-35.

78. Whited JD, Hall RP, Foy ME, et al. Teledermatology's impact on time to intervention among referrals to a dermatology consult service. *Telemed J E Health.* Fall 2002;8(3):313-321.

79. Archbold HA, Guha AR, Shyamsundar S, McBride SJ, Charlwood P, Wray R. The use of multi-media messaging in the referral of musculoskeletal limb injuries to a tertiary trauma unit using: a 1-month evaluation. *Injury.* Apr 2005;36(4):560-566.

80. Beach M, Goodall I, Miller P. Evaluating telemedicine for minor injuries units. *J Telemed Telecare.* 2000;6 Suppl 1:S90-92.

81. Collins K, Nicolson P, Bowns I, Walters S. General practitioners' perceptions of store-and-forward teledermatology. *J Telemed Telecare.* 2000;6(1):50-53.

82. Collins K, Walters S, Bowns I. Patient satisfaction with teledermatology: quantitative and qualitative results from a randomized controlled trial. *J Telemed Telecare.* 2004;10(1):29-33.

83. Collins K, Bowns I, Walters S. General practitioners' perceptions of asynchronous telemedicine in a randomized controlled trial of teledermatology. *J Telemed Telecare.* 2004;10(2):94-98.

84. Loane MA, Bloomer SE, Corbett R, et al. A randomized controlled trial to assess the clinical effectiveness of both realtime and store-and-forward teledermatology compared with conventional care. *J Telemed Telecare.* 2000;6 Suppl 1:S1-3.

85. Mahendran R, Goodfield MJ, Sheehan-Dare RA. An evaluation of the role of a store-and-forward teledermatology system in skin cancer diagnosis and management. *Clin Exp Dermatol.* May 2005;30(3):209-214.

86. Mallett RB. Teledermatology in practice. *Clin Exp Dermatol.* Jul 2003;28(4):356-359.

87. Mandall NA, O'Brien KD, Brady J, Worthington HV, Harvey L. Teledentistry for screening new patient orthodontic referrals. Part 1: A randomised controlled trial. *Br Dent J.* Nov 26 2005;199(10):659-662, discussion 653.

88. Patterson V, Hoque F, Vassallo D, Farquharson Roberts M, Swinfen P, Swinfen R. Store-and-forward teleneurology in developing countries. *J Telemed Telecare.* 2001;7 Suppl 1:52-53.

89. Taylor P, Goldsmith P, Murray K, Harris D, Barkley A. Evaluating a telemedicine system to assist in the management of dermatology referrals. *Br J Dermatol.* Feb 2001;144(2):328-333.

90. Vassallo DJ, Hoque F, Roberts MF, Patterson V, Swinfen P, Swinfen R. An evaluation of the first year's experience with a low-cost telemedicine link in Bangladesh. *J Telemed Telecare.* 2001;7(3):125-138.

91. Baruffaldi F, Gualdrini G, Toni A. Comparison of asynchronous and realtime teleconsulting for orthopaedic second opinions. *J Telemed Telecare.* 2002;8(5):297-301.

92. Larcher B, Arisi E, Berloffa F, et al. Analysis of user-satisfaction with the use of a teleconsultation system in oncology. *Med Inform Internet Med.* Jun 2003;28(2):73-84.

93. Malacarne M, Lesma A, Madera A, et al. Preliminary experience of shared clinical management between Milan and Pointe Noire using the INteractive TeleConsultation Network for Worldwide HealthcAre Services (INCAS): telemedicine between Milan and Africa. *Telemed J E Health.* Winter 2004;10(4):437-443.

94. Eminovic N, Witkamp L, Ravelli AC, et al. Potential effect of patient-assisted teledermatology on outpatient referral rates. *J Telemed Telecare.* 2003;9(6):321-327.

95. Knol A, van den Akker TW, Damstra RJ, de Haan J. Teledermatology reduces the number of patient referrals to a dermatologist. *J Telemed Telecare.* 2006;12(2):75-78.

96. Fortin JP, Gagnon MP, Cloutier A, Labbe F. Evaluation of a telemedicine demonstration project in the Magdalene Islands. *J Telemed Telecare.* 2003;9(2):89-94.

97. Vladzymyrskyy AV. Four years' experience of teleconsultations in daily clinical practice. *J Telemed Telecare.* 2005;11(6):294-297.

98. Chen LS, Tsai CY, Liu TY, et al. Feasibility of tele-ophthalmology for screening for eye disease in remote communities. *J Telemed Telecare.* 2004;10(6):337-341.

99. Baba M, Seckin D, Kapdagli S. A comparison of teledermatology using store-and-forward methodology alone, and in combination with Web camera videoconferencing. *J Telemed Telecare.* 2005;11(7):354-360.

100. Klaz I, Wohl Y, Nathansohn N, et al. Teledermatology: quality assessment by user satisfaction and clinical efficiency. *Isr Med Assoc J.* Aug 2005;7(8):487-490.

101. Moreno-Ramirez D, Ferrandiz L, Galdeano R, Camacho FM. Teledermatoscopy as a triage system for pigmented lesions: a pilot study. *Clin Exp Dermatol.* Jan 2006;31(1):13-18.

102. Hockey AD, Wootton R, Casey T. Trial of low-cost teledermatology in primary care. *J Telemed Telecare.* 2004;10 Suppl 1:44-47.

103. Massone C, Soyer HP, Hofmann-Wellenhof R, et al. Two years' experience with Web-based teleconsulting in dermatology. *J Telemed Telecare.* 2006;12(2):83-87.

104. Hersh WR, Hickam DHS, Severance SM, Dana TL, Krages KP, Helfand M. *Telemedicine for the Medicare Population: Update.* Feb 2006. Publication No. 06-E007.

105. Ho K, Jarvis-Selinger S. *Pan Canadian Environmental Scan of Clinical Telehealth Activity Evidence Companion* 2006.

106. Whitten PS, Mair FS, Haycox A, May CR, Williams TL, Hellmich S. Systematic review of cost effectiveness studies of telemedicine interventions. *BMJ.* Jun 15 2002;324(7351):1434-1437.

107. Roine R, Ohinmaa A, Hailey D. Assessing telemedicine: a systematic review of the literature. *CMAJ.* Sep 18 2001;165(6):765-771.

108. Williams TL, May CR, Esmail A. Limitations of patient satisfaction studies in telehealthcare: a systematic review of the literature. *Telemed J E Health.* Winter 2001;7(4):293-316.

109. Christensen CM, Roth EA, Anthony SD. *Seeing What's Next: Using Theories of Innovation to Predict Industry Change*: Harvard Business School Press; 2004.

110. Shojania KG, Sampson M, Ansari MT, Ji J, Doucette S, Moher D. How quickly do systematic reviews go out of date? A survival analysis. *Ann Intern Med.* Aug 21 2007;147(4):224-233.

111. Moher D, Pham B, Lawson ML, Klassen TP. The inclusion of reports of randomised trials published in languages other than English in systematic reviews. *Health Technol Assess.* 2003;7(41):1-90.

112. Dickersin K, Min YI. Publication bias: the problem that won't go away. *Ann N Y Acad Sci.* Dec 31 1993;703:135-146; discussion 146-138.

113. Thornton A, Lee P. Publication bias in meta-analysis: its causes and consequences. *J Clin Epidemiol.* Feb 2000;53(2):207-216.

114. Hopewell S, McDonald S, Clarke M, Egger M. Grey literature in meta-analyses of randomized trials of health care interventions. *Cochrane Database Syst Rev.* 2007(2):MR000010.

115. Scott RE MF, Jennett PA, Perverseff T, Lorenzetti D, Saeed A, Rush B, Yeo M. Telehealth outcomes: a synthesis of the literature and recommendations for outcome indicators. *J Telemedicine Telecare.* 2007;13(Suppl 2):1-38.

116. Weinstock MA, Kempton SA. Case report: teledermatology and epiluminescence microscopy for the diagnosis of scabies. *Cutis.* Jul 2000;66(1):61-62.

117. Rodas E, Mora F, Tamariz F, Cone SW, Merrell RC. Low-bandwidth telemedicine for pre- and postoperative evaluation in mobile surgical services. *J Telemed Telecare.* 2005;11(4):191-193.

118. Lau J, Ioannidis JP, Schmid CH. Quantitative synthesis in systematic reviews. *Ann Intern Med.* Nov 1 1997;127(9):820-826.

APPENDICES

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