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Teledermatology Services: Rapid Review of Diagnostic, Clinical Management, and Economic Outcomes

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Canadian Agency for Drugs and Technologies in Health

Teledermatology Services: Rapid Review of Diagnostic, Clinical Management, and Economic Outcomes

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October 2010

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TABLE OF CONTENTS

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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 Panel members or reviewers.

Conflicts of Interest

Dr. Jaggi Rao is the founder of a store-and-forward teledermatology project called "Consult Derm".

EXECUTIVE SUMMARY

Context and Policy Issues

The demand for specialized dermatology care has grown. In Canada, an estimated 89% of dermatologists practice in urban areas, 19% practice in a rural area, and less than 0.5% practice in remote areas. Some dermatologists practice in more than one setting. Teledermatology offers the potential to provide dermatological care to those living in rural or remote areas, to limit unnecessary referrals, and to reduce wait times for outpatient consultations. Store-and-forward (asynchronous) teledermatology is the electronic transmission of static digital images and clinical history to a dermatologist to review at a later time. Teledermoscopy involves the use of an epiluminescence microscope to create digital dermoscopic images. Live interactive (synchronous) teledermatology uses video conferencing equipment and image transmission to link the patient, referrer, and dermatologist in real time. For widespread, sustainable adoption of teledermatology services to occur, efficacy, acceptability, and economic viability need to be demonstrated. This report reviews evidence on the diagnostic, clinical management, and economic outcomes in teledermatology to guide implementation initiatives.

Research Questions

1. What is the diagnostic accuracy and reliability of teledermatology consultations compared with current practice in remote or rural areas?
2. What are the benefits of teledermatology consultations with regard to patient outcomes, wait times, avoidance of unnecessary clinic visits, patient-incurred costs, and patient satisfaction?
3. What are the economic impacts of teledermatology consultations to the health care system?

Methods

A literature search was conducted on key health technology assessment resources, including MEDLINE, Embase, The Cochrane Library (Issue 3, 2010), ECRI (Health Devices Gold), international health technology agencies, and a focused Internet search. The search was limited to English language articles published between January 1, 2005 and April 6, 2010. Regular alerts are current to May 11, 2010. No filters were applied to limit the retrieval by study type. One reviewer screened the titles and abstracts, and evaluated selected full-text publications for final article selection using predefined criteria. The final selection was verified by a second reviewer.

Summary of Findings

Four randomized controlled trials (RCTs) were identified. The results of one cluster randomized trial (85 general practitioners, 631 patients) indicated that store-and-forward teledermatology may reduce general practitioner referrals to a dermatologist by approximately 20%. A second RCT (n = 457) reported high intraobserver diagnostic and treatment reliability for various dermatologic conditions when store-and-forward teledermatology was compared with face-to-face consultations. Adding video conferencing to store-and-forward data did not increase the diagnostic or treatment reliability. The results from a third RCT (n = 698) showed no statistically significant differences in clinical course for various indications when comparing store-and-forward teledermatology with clinic-based care. A fourth RCT (n = 208) reported that store-and-forward teledermatology failed to achieve diagnostic and management equivalence compared with face-to-face consultations. Additional results from a non-randomized arm of the study suggested that digital photography and dermoscopy images were unlikely to alter the need for face-to-face consultations without affecting clinical safety in patients with suspected skin cancer. Issues in study design, low recruitment, and high attrition rates may have affected the validity of these findings.

Most of the eight non-randomized comparative studies that were identified assessed the reproducibility (diagnostic reliability) of teledermatology compared with itself or with face-to-face consultations. The results showed that teledermatology consultations using store-and-forward teledermatology or live-interactive teledermatology resulted in highly reliable diagnoses and management plans that compared favorably with conventional clinic-based care. In one study, the addition of video conferencing to store-and-forward teleconsultations did not significantly improve the diagnostic or management plan agreement of store-and-forward teleconsultations compared with clinic-based care. Some studies indicated that teledermoscopy may be useful in the diagnosis of skin cancers and non-pigmented skin lesions, but not for pigmented lesions or atypical lesions.

Diagnostic accuracy was less studied because of the lack of a gold standard test that can be applied across all dermatologic diseases. Two studies reported that store-and-forward teledermatology achieved similar diagnostic accuracy compared with conventional face-to-face clinic consultations. One of these studies found that adding web camera video conferencing to store-and-forward teledermatology statistically significantly increased diagnostic accuracy compared with store-and-forward teledermatology. Two studies reported a statistically significantly lower diagnostic accuracy when store-and-forward teledermatology was compared with face-to-face diagnosis in patients with pigmented and non-pigmented lesions. Teledermatology consultations resulted in a statistically significantly higher rate of inappropriate management plans that were potentially life-threatening compared with face-to-face consultations for pigmented neoplasms. Intermediate clinical outcomes such as time to clinic attendance, time to treatment, and avoidance of unnecessary referrals were all improved with the use of teledermatology.

Four economic evaluations were identified. Two cost-effectiveness studies found store-and-forward teledermatology to be the dominant intervention from a societal perspective compared with conventional care for the management of patients with skin cancers in Spain. Both these studies assumed a public health setting with an established telecommunications infrastructure. One cost-minimization study found direct costs to be higher with store-and-forward teledermatology compared with conventional care for the management of patients with various dermatologic conditions. When the costs of lost productivity were considered, store-and-forward teledermatology was found to be cost-saving. Another cost-minimization study found live interactive teledermatology to be economically viable from the health care provider perspective for the management of various dermatologic conditions as compared with conventional care.

Limitations

Many of the identified studies were performed in experimental clinical settings with investigators pre-selecting lesions for evaluation. Therefore, the results may not have been representative of routine adult dermatology referrals and teledermatology systems in clinical practice. Small sample size and non-diverse study populations may have limited the generalizability of some results. Low recruitment and high attrition rates may have limited the validity of findings from RCTs. The intraobserver design of some studies may have biased results in favour of teledermatology in the absence of blinding to prevent recall bias. In one study that assessed clinical outcomes, there were several limitations in the generalizability of findings to patients with different dermatologic conditions. Most studies assessed intermediate clinical outcomes such as time to clinic attendance, time to treatment, and avoidance of unnecessary referrals. It is unclear whether improvements in intermediate clinical outcomes results in better health outcomes. None of the economic studies were conducted in Canada, thereby limiting the extent to which findings may be generalized to a Canadian setting.

Conclusions and Implications for Decision- or Policy-Making

Teledermatology may be beneficial for geographically isolated patients who would not otherwise be seen by a dermatologist. The largest body of research focuses on the diagnostic reliability of teledermatology. The evidence shows that teledermatology consultations — whether using store-and-forward, live interactive, or hybrid techniques — result in highly reliable diagnoses and management plans that compare favourably with those of conventional clinic-based care.

The evidence that store-and-forward teledermatology or teledermoscopy can be used to accurately predict disease compared to gold standard tests is conflicting. Teleconsultations were statistically significantly less accurate compared with clinic-based care in studies that exclusively used histopathology results as the reference diagnostic standard. This finding is particularly concerning in the field of skin cancer, where a misdiagnosis could lead to significant morbidity and mortality. No recent studies have assessed diagnostic accuracy when using live interactive teledermatology alone.

There is consistent evidence that teledermatology improves wait times and decreases the number of unnecessary referrals. Whether this translates into improved health outcomes for patients living in rural areas is unclear. Overall, patient satisfaction did not differ between groups receiving teledermatology or conventional clinic-based care. The concerns that were reported by general practitioners included the complexity of the teledermatology system, a time-consuming process, and an increased workload. Teleconsultant concerns included a lack of patient contact and less confidence in the diagnosis made using teledermatology.

Economic evaluations found store-and-forward teledermatology to be cost-saving from a societal perspective for the management of patients with skin cancer. It is unclear whether the implementation of teledermatology services using existing technologies would be cost-effective based on the specific geographic requirements in rural Canadian settings. There is no evidence to support the cost-effectiveness of live interactive teledermatology. Larger and more comprehensive studies assessing patient outcomes such as harm resulting from missed diagnoses or incorrect treatments in different dermatologic indications will better define the value of teledermatology and guide implementation decisions.

1 CONTEXT AND POLICY ISSUES

The demand for specialized dermatology care has grown. The results of a 2001 survey highlight the shortage of dermatology services in rural and remote locations in Canada.[1] An estimated 89% of dermatologists practiced in urban areas, 19% practiced in a rural area, and less than 0.5% practiced in remote areas.[1] Some dermatologists practiced in more than one setting. Fifty percent of dermatologists reported that they planned to reduce their practices or retire within five years.[1] Teledermatology is the use of imaging and telecommunication technologies to provide dermatology services to other health professionals (usually a general practitioner) or to a patient.[2] Teledermatology offers the potential to provide dermatological care to those living in rural or remote areas, to limit unnecessary referrals, and to reduce wait times for outpatient consultations.[3]

Two consultation modalities are used in teledermatology. Store-and-forward (asynchronous) teledermatology is the electronic transmission of static digital images to a dermatologist to review at a later time.[3] These images are typically bundled in a consultation package that contains clinical history and demographic information. Store-and-forward teledermatology does not allow the specialist to take a direct history, palpate lesions, or communicate the purpose of management to the patient or referrer. Teledermoscopy is an application of store-and-forward teledermatology involving the use of an epiluminescence microscope to create digital dermoscopic images.[4] Live interactive (synchronous) teledermatology uses video conferencing equipment and image transmission to connect the patient, referrer, and dermatologist in real time.[3] The dermatologist and patient can verbally interact in a manner similar to a traditional clinic-based encounter. Compared with store-and-forward teledermatology, more time and a more extensive telecommunications infrastructure are needed in live interactive consultations.[3] Hybrid models that combine store-and-forward and live-interactive applications are also available.

For widespread, sustainable adoption of teledermatology services to occur, efficacy, acceptability, and economic viability need to be demonstrated. This report reviews evidence on the diagnostic, clinical management, and economic outcomes in teledermatology to guide implementation initiatives.

2 RESEARCH QUESTIONS

1. What is the diagnostic accuracy and reliability of teledermatology consultations compared with current practice in remote or rural areas?
2. What are the benefits of teledermatology consultations with regard to patient outcomes, wait times, avoidance of unnecessary clinic visits, patient-incurred costs, and patient satisfaction?
3. What are the economic impacts of teledermatology consultations to the health care system?

3 METHODS

Literature search

Peer-reviewed literature searches were conducted to obtain published literature for this review. All search strategies were developed by an Information Specialist with input from the project team.

The following bibliographic databases were searched through the Ovid interface: MEDLINE, MEDLINE In-Process & Other Non-Indexed Citations, and Embase. Parallel searches were run in PubMed and The Cochrane Library (Issue 3, 2010). The search strategy was comprised of both controlled vocabulary, such

as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. No filters were applied to limit the retrieval by study type. Appendix 1 shows the detailed search strategies.

The search was restricted to English language clinical articles published between January 1, 2005 and April 6, 2010. Regular alerts were established on Embase and MEDLINE, and information that was retrieved via alerts was current to May 11, 2010.

Grey literature (literature that is not commercially published) was identified by searching the websites of health technology assessment and related agencies, professional associations, and other specialized databases. Google and other Internet search engines were used to search for additional web-based materials and information. These searches were supplemented by handsearching the bibliographies and abstracts of key papers.

Article selection

One reviewer (SN) screened titles and abstracts of the search output and evaluated the selected full-text publications for final article selection using predefined inclusion and exclusion criteria. The final selection was verified by a second reviewer (WP-P).

The criteria for inclusion were:

Population	Adult patients living in remote or rural areas and needing consultation with dermatologists for medical diagnosis and treatment initiation.
Intervention	Teledermatology technologies used for dermatologist consultation with patients or general practitioner.
Comparator	Face-to-face consultations or usual care.
Outcomes	Patient (morbidity, mortality, quality of life), efficiency (wait times, avoidance of unnecessary dermatologist visits), diagnostic accuracy, diagnostic reliability, patient satisfaction with care, provider satisfaction with teledermatology system, costs, cost-effectiveness.
Study design	Systematic reviews, systematic review-based meta-analyses, randomized controlled trials (RCTs), non-randomized comparative studies, observational studies, economic studies.

The criteria for exclusion included:

- Exploratory, feasibility, or pilot studies
- Studies assessing chronic management outcomes including wound care (for example, leg ulcers, diabetic foot), and home monitoring of dermatologic conditions
- Retrospective observational studies
- Non-comparative studies
- Studies of children exclusively
- Studies assessing technical aspects of teledermatology.

A glossary of relevant terms is provided in Appendix 2. This report was peer-reviewed by two clinical experts and one economic expert.

4 SUMMARY OF FINDINGS

Of the 284 citations that were identified in the literature search, 214 were excluded after screening of titles and abstracts, and 70 were retrieved for full-text screening. Sixteen publications were included in this report, and the remaining 54 articles were excluded (Appendix 3). Four RCTs,[6-9] eight non-randomized comparative studies,[4,10-16] and four economic evaluations[17-20] were identified. The literature search did not identify any systematic reviews or meta-analyses that fit the inclusion criteria.

Randomized controlled trials

The study objectives, methods, outcomes, and author conclusions from four RCTs[6-9] are summarized in Table 1.

The results of a cluster randomized trial by Eminovic et al. showed that store-and-forward teledermatology may reduce general practitioner referrals to a dermatologist for various indications by approximately 20%.[6] Consultations were judged as preventable if patients experienced full or partial recovery, the condition was considered treatable by a general practitioner, or the patient could not be treated. Consultations were considered to be non-preventable if advice received from the teledermatology consultation was incorrect, the services of a dermatologist were required for treatment, or the patient requested a face-to-face consultation. More than half (51.3%) of the preventable consultations were due to full or partial recovery. A minority (9%) of non-preventable consultations were due to incorrect teledermatology consultation advice. The validity of these findings is limited by a drop in recruitment due to participants not visiting a dermatologist or general practitioner after inclusion in the study or because of improper study form completion. Of 631 randomized participants, 369 (58.5%) were analyzed for preventable consultations. However, sensitivity analyses including data collected after the office visit indicated robustness of the results. This may not have been a representative sample, because some general practitioners may have been selective when inviting patients to participate in the study.

Romero et al. reported high intra-observer diagnostic and treatment reliability in an RCT comparing store-and-forward teledermatology with face-to-face consultations for various dermatologic conditions.[7] Adding video conferencing to store-and-forward data did not increase the diagnostic or treatment reliability. The intra-observer design may have falsely increased reliability, particularly because there was no mention of blinding to prevent recall bias.

Pak et al. compared the clinical outcomes achieved after using store-and-forward teledermatology with those observed with conventional clinic-based care in patients who were referred from US Department of Defense primary care clinics.[8] The results showed no statistically significant differences in clinical course for various indications based on a three-point rating scale (1 = improved, 2 = no change, 3 = worse) when comparing the teledermatology and conventional groups. Several trial limitations were noted. Of 698 randomized participants, 508 (72.8%) underwent image review. The rate of withdrawal was higher among patients in the control group compared with the teledermatology group (32% versus 23%, respectively). Details regarding the dermatologic indications that were assessed were lacking. It is unlikely that the rating scale that was used in the trial would be reliable across all dermatologic conditions. Furthermore, only a fair level of inter-rater reliability (kappa = 0.25) was achieved. The use of digital images to assess clinical course may have biased the results in favour of teledermatology. It is unclear whether these results are generalizable to non-military populations.

Bowns et al. reported that store-and-forward teledermatology failed to achieve diagnostic and management equivalence compared with face-to-face consultations.[9] Several trial limitations suggest that these results may not represent a valid comparison. First, the study failed to achieve the recruitment target of 892 patients as estimated based on pre-study calculations. Instead, 208 participants were recruited.

Second, 165 (79.3%) randomized participants were available for analysis. The withdrawal rate was higher in the control group (24.7%) than the teledermatology group (17.1%). Third, the delay in obtaining the second opinion to determine agreement between groups (54 days longer in the intervention group) allowed the potential for the skin condition to change as a result of spontaneous resolution or interim treatment by the general practitioner. Fourth, the generalizability of these findings is questionable considering that patient groups were recruited and managed by a highly selected subgroup of general practitioners. Recruitment issues occurred at the practitioner level (a small number and proportion of general practitioners recruited most of the patients) and at the patient level (a small minority of eligible patients seem to have been recruited). The patients who were recruited may not have been representative of routine adult dermatology referrals. Additional results from patients with suspected skin cancer in a non-randomized arm of the study suggested that digital photography and dermoscopy images are unlikely to alter the need for face-to-face consultations without affecting clinical safety.

Table 1: Results from RCTs Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions**
Eminovic et al. (2009)[6] Cluster RCT			
To determine if SF teledermatology consultations reduce referrals to a dermatologist by GPs.	85 randomized GPs from 35 general practices in 2 regions of The Netherlands enrolled 631 patients (46 intervention GPs, 327 patients; 39 control GPs, 304 patients). For SF teledermatology group, the GPs took digital images and attached patients' histories for teleconsultation within 48 hours. Control group received a referral letter and waited for the clinic visits. All patients visited 1 of 5 dermatologists at 1 month (regular waiting time), irrespective of the degree of recovery. SF teledermatology group visited the same dermatologist who had performed the teleconsultation. The proportion of office visits prevented by teleconsultation was determined. Mean age (years) SF teledermatology: 42 ± 23 Control: 44 ± 20 Male sex (%) SF teledermatology: 44 Control: 36	**Preventable consultations** SF teledermatology: 78/200 (39.0%) Control: 31/169 (18.3%) Difference: 20.7% (95% CI 8.5% to 32.9%; p < 0.001) **Preventable consultation reason** SF teledermatology: Full/partial recovery 40/78 (51.3%) GP treatable 30/78 (38.5%) Control: Full/partial recovery 7/31 (22.6%) GP treatable 21/31 (67.7%) **Non-preventable consultation reason** SF teledermatology: Incorrect teleconsultation advice 11/122 (9.0%) Dermatologist required for treatment 87/122 (71.3%) Patient request 4/122 (3.3%) Control: Dermatologist required for treatment 94/138 (68.1%) Patient request 16/138 (11.6%) **Preventable consultation by diagnosis** SF teledermatology: Benign skin tumour 6/27 (22.2%) Eczema 15/29 (51.7%) Infection 11/18 (61.1%) Malignant skin tumour 0/1 (0.0%) Psoriasis 5/11 (45.5%) Acne 2/5 (40.0%) Pigmented lesion 3/7 (42.9%)	SF teledermatology consultations may reduce GP referrals to a clinic dermatologist by 20%.

Table 1: Results from RCTs Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions**
		Premalignant tumour 1/4 (25.0%) Control: Benign skin tumour 4/34 (11.8%) Eczema 6/22 (27.3%) Infection 2/11 (18.2%) Malignant skin tumour 0/6 (0.0%) Psoriasis 0/4 (0.0%) Acne 2/10 (20.0%) Pigmented lesion 3/10 (30.0%) Premalignant tumor 3/12 (25.0%) **Patient satisfaction** No differences found between groups.	
Romero et al. (2009)[7] RCT			
To evaluate the reliability of two remote consultation techniques.	Patients referred to specialized care from 6 local health centers in Spain were randomized to 3 groups: SF teledermatology (n = 192), hybrid system (SF in combination with LI web camera video conferencing) (n = 176), and control (n = 89). The remote SF consultation was based solely on clinical data and digital photographs. In LI-SF group, photographs and clinical data were assessed, followed by a video conferencing session via webcam with both GP and patient present. No new photographs could be included. Two days after the remote consultation, all patients were also seen by the same dermatologist in a FTF consultation	**Diagnostic agreement** Intra-observer agreement between FTF and remote consultations was high in the SF and LI-SF groups, with complete agreement > 0.85 and disagreement < 0.08. Complete agreement was 0.86 for tumours, 0.86 for eruptions, 1.00 for acne, and 0.94 for infections. There were no statistically significant differences between groups (p = 0.34). One serious error from teleconsultation occurred in the LI-SF group, with the incorrect diagnosis of herpes simplex instead of pemphigus vulgaris. **Diagnostic confidence** In 89.3% of remote consultations, confidence in diagnosis was high or very high, with no statistically significant differences between groups (p = 0.44).	Intra-observer diagnostic and treatment reliability between FTF and remote consultations is high. When history-taking and training in digital photography is standardized, a hybrid system with video conferencing does not significantly enhance the diagnostic or treatment reliability of SF teleconsultations alone.

Table 1: Results from RCTs Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions**
	(considered the practical reference standard). Two independent dermatologists assessed diagnostic agreement between the teledermatology and FTF consultation. Diagnostic self-reported confidence was rated on a Likert scale from 1 (no confidence) to 5 (complete confidence). Mean age 36 years (range 2 months to 86 years), 44% male.	**Treatment agreement** Treatment was identical for 78.5% of LI-SF and 85.3% of SF cases (p = 0.27). Degree of agreement between FTF and remote consultation was very high, both in request for diagnostic tests (concordant in 91.8% of LI-SF cases and 95.9% SF cases) and in need for follow-up of patients (concordant in 90.5% of LI-SF cases and 95.9% of SF cases).	
Pak et al. (2007)[8] RCT			
To compare the clinical outcomes of SF teledermatology with those following conventional clinic-based consultation.	Patients referred from 4 US Department of Defense primary care clinics to 1 of 2 dermatology clinics (dermatologic indications not specified) were randomized to SF teledermatology (n = 351) or conventional clinic-based consultation (n = 347). The SF teledermatology consultation included a standardized history and digital images. A dermatologist reviewed the teledermatology consultation and could either schedule a clinic-based encounter, or send a diagnosis and/or management plan to the referring clinician. Clinical outcomes were assessed by obtaining a baseline set of images and a second set of images 4 months later in both study groups. A dermatologist	**Clinical course rating** SF teledermatology: 173/272 (64%) improved 89/272 (33%) no change 10/272 (4%) worse Clinic-based: 154/236 (65%) improved 76/236 (32%) no change 3/236 (3%) worse No statistically significant difference found in clinical course (p = 0.57). **Rating scale reliability** Simple agreement = 0.62; K = 0.25	There is no difference in clinical course outcomes when SF teledermatology consultations are compared with conventional clinic-based consultations.

Table 1: Results from RCTs Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions**
	blinded to study group assignment rated clinical course using a 3-point clinical course rating scale based on the images. Inter-rater reliability was assessed in a random sample of 50 images using an independent dermatologist. Mean age (years) SF teledermatology: 43.6 Control: 46.8 (p = 0.02) Male sex (%) SF teledermatology: 29 Control: 34 (p = 0.17)		
Bowns et al. (2006)[9] RCT			
To compare the clinical equivalence of SF teledermatology with conventional FTF consultation in setting a management plan for new adult outpatient referrals (RCT). To assess the equivalence of digital photography with or without dermoscopy with conventional FTF consultations for the management of suspected cases of malignant melanoma	Adults referred from 8 general practices in England requiring a new consultant opinion were randomized to the SF teledermatology group (n = 111) or conventional control group (n = 97). For the first objective, patients in the teleconsultation group were managed using one or more digital still images and a structured electronic referral and reply. The control group was managed by conventional hospital outpatient consultations. The main outcome measure was the agreement between the teleconsultation or FTF consultation with another blinded consultant who gave a second FTF opinion. This occurred the same day for patients in	**Diagnostic agreement** SF teledermatology: 51/92 (55%) Control: 57/73 (78%) Difference -23% (95% CI: -36% to -8%; p = 0.002) **Management agreement** SF teledermatology: 51/92 (55%) Control: 61/73 (84%) Difference -28% (95% CI: -40% to -14%; p = 0.0001) 53/92 (57.6%) teledermatology cases were judged to require a FTF consultation, mainly to establish a diagnosis and treatment plan. **Digital photography with dermoscopy** Diagnostic agreement on whether or not the lesion was malignant was modest (68%).	For the first objective, no conclusions can be drawn regarding SF teledermatology due to difficulties in recruitment, selective loss of patients, and a delay in obtaining a valid FTF second opinion in the teleconsultation group. Regarding the second objective, digital photography and dermoscopy images are unlikely to alter the need for standard consultations without sacrificing clinical safety.

Table 1: Results from RCTs Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions**
or squamous cell carcinoma (non-randomized comparative study).	the control group, but with a mean delay of 54 days in the teleconsultation group. For the second objective, patients (n = 256) with suspicion of malignant melanoma or squamous cell carcinoma were invited to have a series of digital photographs with and without dermoscopy, immediately before their FTF consultation. A second teleconsultant viewed the images and outlined a diagnosis and management plan. This was compared with the definitive diagnosis (either final clinical or histological diagnosis) of the FTF consultation. Mean age (years) SF teledermatology: 43.6 ± 17.8 Control: 49.7 ± 19.8 (p = 0.039) Male (%): SF teledermatology: 37 Control: 38 (p = 0.85)	The approach was highly sensitive (98%; 95% CI 92% to 99%), but not specific (43%; 95% CI 36% to 51%). Overall, 180/256 (70.3%) of cases would have needed to be seen FTF. **Patient satisfaction** Patient satisfaction was high in both groups (81.3% teledermatology, 89.6% control), with no statistically significant difference between groups. 76% of patients in the teleconsultation group would rather be managed by teledermatology than have to wait several weeks for a clinic appointment. **GP satisfaction** 7/22 (21%) of respondents felt satisfied with teledermatology in their practice. Concerns included a time-consuming process, increased workload, and a complex teledermatology system. **Consultant satisfaction** Teleconsultants felt teledermatology was easy to use. Concerns included lack of patient contact and less confidence in diagnosis.	

CI = confidence interval; FTF = face-to-face; GP = general practitioner; K = kappa value; LI = live interactive; RCT = randomized controlled trial; SF = store-and-forward; US = United States.

Non-randomized comparative studies

The objectives, methods, outcomes, author findings, and limitations from eight selected studies[4,10-16] are summarized in Table 2.

Overall, most of the studies assessed the diagnostic reliability of teledermatology compared with conventional care. The results showed that teledermatology consultations, using store-and-forward teledermatology or live-interactive teledermatology, resulted in highly reliable diagnoses that compared favourably with conventional clinic-based care.[13,15,16] The management plan agreement for various dermatologic indications ranged from moderate to substantial.[13,15] In one study, the addition of video conferencing to store-and-forward teleconsultations did not significantly improve the diagnostic or management agreement of store-and-forward teleconsultations alone compared with clinic-based care.[13] Some studies indicated that teledermoscopy may be useful in the diagnosis of skin cancers[10,14] and non-pigmented skin lesions,[11] but not for pigmented lesions or atypical lesions.[4,12]

Diagnostic accuracy was less studied because of the lack of a gold standard test that can be applied across all dermatologic diseases.[3] In some studies, the authors used face-to-face, clinic-based consultations as a pragmatic gold standard. Two studies reported that store-and-forward teledermatology achieved comparable diagnostic accuracy compared with conventional face-to-face clinic consultations.[15,16] One of these studies found that adding web camera video conferencing to store-and-forward teledermatology statistically significantly increased diagnostic accuracy compared with store-and-forward teledermatology.[16] Because new photographs could be sent during the live interactive session, the results may have been biased toward the hybrid group. Conflicting evidence is reported in two studies that evaluated diagnostic accuracy using histopathology results as the reference standard in patients with pigmented and non-pigmented lesions.[11,12] Both studies found store-and-forward teledermatology to be statistically significantly less accurate than face-to-face diagnosis. Despite this finding, store-and-forward teledermatology and face-to-face dermatology were equally effective in determining when lesions required biopsy or removal.[11,12] Teledermatology consultations resulted in a statistically significantly higher rate of inappropriate management plans that were potentially life-threatening compared with face-to-face consultations for pigmented neoplasms.[12] No recent information is available on the diagnostic accuracy of using live interactive teledermatology alone.

Intermediate clinical outcomes such as time to clinic attendance, time to treatment, and avoidance of unnecessary referrals (the skin condition could be managed by a general practitioner using teleconsultation advice or the patient did not need therapy and follow-up at a clinic) were all improved with the use of teledermatology.[10,14,15]

Table 2: Summary of Results from Non-randomized Comparative Studies Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions and Limitations**
Tan et al. (2010)[10] Diagnostic agreement			
To assess teledermoscopy as a triage tool to improve access to public hospital skin lesion clinics.	Patients (n = 200; 491 lesions) with suspected skin cancers referred by a GP to a dermatology skin lesion clinic in New Zealand. Digital and dermoscopic images were taken of skin lesions. Patients were then seen independently FTF by 2 of 3 dermatologists. Digital and dermoscopic images were evaluated 4 weeks later (to minimize recall bias) as a teledermoscopy consultation by 2 of these dermatologists. All identifying data were removed. Teledermoscopy was compared with FTF as gold standard (except where histopathologic diagnosis was available). Age range 11 to 94 years, 37% male.	**Diagnostic agreement** 597/681 (87.7%) K = 0.95 (95% CI 0.91 to 0.98) 12 lesions were initially diagnosed as malignant when seen FTF, but were considered benign on teledermoscopy. On histological examination, only 1 lesion was found to be malignant. **Diagnostic accuracy** Teledermoscopy achieved 100% sensitivity and 90% specificity for detecting melanoma and non-melanoma skin cancers. **Inter-observer agreement:** Teledermoscopy: 422/492 (85.9%) K = 0.92 (0.82 to 0.96) FTF (among 3 dermatologists): Range 83.5% to 89.5% (K > 0.9 for all comparisons) **Avoidance of unnecessary referrals** Of the referrals to the lesion clinic, 136 (68%) patients were determined to be manageable by a GP following advice from the teledermoscopy consultation.	Teledermoscopy may be used as a triage tool to shorten waiting lists and improve health care access and delivery. **Limitations** The same dermatologist performed the FTF and teledermoscopy consultation, introducing the possibility of recall bias. This was minimized by a 4-week "wash out" period to reduce recollection of patients. Small sample of patients evaluated.

Table 2: Summary of Results from Non-randomized Comparative Studies Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions and Limitations**
Warshaw et al. (2009)[11] Cross-sectional repeated-measures equivalence trial			
To assess the equivalence of SF teledermatology with or without dermoscopic images for the diagnosis and management of non-pigmented neoplasms with FTF dermatology.	US veterans (n = 728) with non-pigmented skin lesions were evaluated by a clinic dermatologist and by an independent dermatologist using SF teledermatology (electronically transmitted clinical digital photographs and a standardized history). Both generated a primary diagnosis and up to 2 differential diagnoses, and a management plan. The primary outcome was aggregated diagnostic accuracy (defined as agreement of the primary diagnosis or any of the differential diagnoses with the histopathology results) and management plan accuracy (judged in reference to the management plan generated by a dermatology expert panel based on histopathologic diagnoses). Secondary outcomes included evaluation of the incremental effect of using polarized light dermoscopy in addition to standard digital images and evaluating benign and malignant lesion subgroups separately. The equivalence analysis assessed if the absolute difference in accuracy between teledermatology and clinic-based dermatology was less than 10%	**Diagnostic accuracy** SF teledermatology was not equivalent and statistically inferior to FTF dermatology for both aggregated and primary diagnoses for all lesions and benign or malignant subgroups. When dermoscopic images were used, the aggregated diagnostic accuracy was statistically significantly better compared with using digital images alone ($p = 0.0017$) but still statistically inferior to FTF dermatology, with the exception of the malignant lesion subgroup. For the malignant lesion subgroup (n = 383), the addition of dermoscopic images yielded equivalent diagnostic accuracy with FTF. **Management plan accuracy** SF teledermatology and FTF dermatology were equivalent. The addition of dermoscopic images did not significantly improve management plan accuracy ($p = 0.47$)	SF teledermatology and FTF dermatology were equally effective in determining when a non-pigmented lesion required biopsy or removal even though the diagnostic accuracy of SF teledermatology was inferior to FTF dermatology. The addition of dermoscopic images plays an important role in the diagnosis of malignant non-pigmented lesions. **Limitations** Non-diverse study population.

Table 2: Summary of Results from Non-randomized Comparative Studies Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions and Limitations**
	(95% CI for the difference in accuracy lies entirely within +/- 10%). Statistical significance for the difference was also tested (95% CI lies below zero). Mean age 71 years (range 21 to 94 years), 97.8% male.		
Warshaw et al. (2009)[12] Cross-sectional repeated-measures equivalence trial			
To assess the equivalence of SF teledermatology with or without dermoscopic images for the diagnosis and management of pigmented neoplasms with FTF dermatology.	US veterans (n = 542) with pigmented skin lesions were evaluated by a clinic dermatologist and by an independent dermatologist using SF teledermatology (electronically transmitted clinical digital photographs and a standardized history). Both generated a primary diagnosis and up to 2 differential diagnoses, and a management plan. The primary outcome was aggregated diagnostic accuracy (defined as agreement of the primary diagnosis or any of the differential diagnoses with the histopathology results) and management plan accuracy (judged in reference to the management plan generated by a dermatology expert panel based on histopathologic diagnoses). Secondary outcomes included evaluation of the incremental effect of using polarized light dermoscopy or contact immersion dermoscopy in addition to standard digital images and evaluating benign and malignant lesion subgroups separately.	**Diagnostic accuracy** SF teledermatology was not equivalent and statistically inferior to FTF dermatology for both aggregated and primary diagnoses for all lesions and benign or malignant subgroups. In general, the addition of dermoscopic images did not significantly change accuracy rates. **Management plan accuracy** Overall, teledermatology management plans were equivalent with FTF dermatology. Subgroup analysis showed that management plan accuracy with teledermatology was statistically superior to clinic dermatology for benign lesions (n = 418) but statistically inferior for malignant lesions (n = 124). Teledermatology resulted in a statistically significantly higher rate of inappropriate management plans that	SF teledermatology with or without dermoscopic images should be used with caution for patients with suspected malignant pigmented lesions. **Limitations** Non-diverse study population and small number of melanomas for subgroup analysis.

Table 2: Summary of Results from Non-randomized Comparative Studies Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions and Limitations**
	The equivalence analysis assessed if the absolute difference in accuracy between teledermatology and clinic-based dermatology was less than 10% (95% CI for the difference in accuracy lies entirely within +/- 10%). Statistical significance for the difference was also tested (95% CI lies below zero). Mean age 66 years (range 23 to 94 years), 95.8% male.	were potentially life-threatening (2.21%) when compared with FTF dermatology (0.37%) (P = 0.0016). This was not improved by the addition of dermoscopic images. 7/36 melanomas (19.4%) would have been mismanaged via teledermatology compared with 1/36 (2.8%) with FTF dermatology.	
Edison et al. (2008)[13] Diagnostic agreement			
To compare LI and SF teledermatology with FTF consultations for diagnostic and management agreement, and diagnostic confidence.	Four dermatologists in random rotation among SF, LI, and FTF care modalities examined 110 new patients with various dermatologic conditions referred to a US dermatology clinic. Diagnostic self-reported confidence was rated on a Likert scale from 1 (no confidence) to 5 (complete confidence). Average age 42 years (range 7 to 92 years), 30.9% male.	**Inter-observer diagnostic agreement** FTF, LI, and SF: 70/110 (64%) FTF and LI: 88/110 (80%) K = 0.79 (95% CI 0.75 to 0.83) FTF and SF: 80/110 (73%) K = 0.71 (95% CI 0.67 to 0.76) SF and LI: 77/110 (70%) K = 0.68 (95% CI 0.64 to 0.73) There were no significant differences (p = 0.13) in diagnostic reliability between LI and SF modalities with respect to FTF standard. **Inter-observer complete diagnostic confidence** FTF 96/110 (87%) LI 65/110 (59%) SF 60/110 (54%)	Results suggest comparable diagnostic and management agreement with LI or SF teledermatology and FTF. Dermatologists were more confident with FTF examination than either form of teledermatology. **Limitations** No details of dermatologist blinding to prevent recall bias and small sample size.

Table 2: Summary of Results from Non-randomized Comparative Studies Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions and Limitations**
		Diagnostic confidence for LI and SF were both statistically significantly lower ($p < 0.0001$) than FTF, although SF and LI were not significantly different from each other ($p = 0.500$). **Inter-observer management agreement** FTF, LI, and SF: 62/110 (56%) FTF and LI: 82/110 (75%) K = 0.709 (95% CI 0.640 to 0.778) FTF and SF: 73/110 (66%) K = 0.618 (95% CI 0.551 to 0.686) SF and LI: 70/110 (64%) K = 0.585 (95% CI 0.517 to 0.654) No statistically significant differences ($p = 0.150$) in management reliability between LI and SF modalities with respect to FTF standard.	
May et al. (2008)[14] Cohort study, service evaluation			
To evaluate SF teledermatology for the triage of melanoma and squamous cell carcinoma at a skin cancer clinic in the UK.	451 new patients were assessed by teledermoscopy (electronic referral with digital and dermoscopic images) to allocate priority. Patients with suspected melanoma or SCC were given an urgent appointment. Data were prospectively collected for 1 year and compared with conventional referral. Age and gender NR.	**Median clinic visit waiting time** Teledermoscopy: Melanoma 14 days (range 1 to 34 days) SCC 13.5 days (range 11 to 19 days) FTF consultation: Melanoma 24 days (range 6 to 59 days) SCC 24 days (range 1 to 42 days) **Time to treatment** Teledermoscopy: Melanoma 21.5 days (range 7 to 47 days)	Teledermoscopy provides a useful triage system for the management of potentially malignant skin lesions by improving prioritization and reducing waiting times.

Table 2: Summary of Results from Non-randomized Comparative Studies Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions and Limitations**
		SCC 56 days (range 37 to 167 days) FTF consultation: Melanoma 41 days (range 14 to 119 days) SCC 73 days (range 1 to 248 days)	
Fabbrocini et al. (2008)[4] Diagnostic agreement			
To determine the diagnostic reliability between FTF diagnosis and SF teledermatology with or without dermoscopic images for rare and atypical lesions.	44 "pink" lesions (defined as lesions with poor and/or absent pigmentation, absence of a regular network, and diameter < 5 mm) were examined by 2 different clinic dermatologists in Italy. Teledermoscopy consultations based on digital and dermoscopic images were performed by the same 2 clinic dermatologists (the first conducted 28 FTF consultations and 16 tele-consultations; the second conducted 16 FTF consultation and 28 tele-consultations). Inter-observer agreement was determined for melanocytic lesions. Diagnostic accuracy for FTF consultation or teleconsultation was evaluated using histopathology results as the reference standard. Age and gender NR.	**Inter-observer diagnostic agreement (melanocytic lesions)** Clinical diagnosis K = 0.362 Dermoscopic diagnosis K = 0.435 **Diagnostic accuracy** FTF clinical diagnosis K = 0.520 FTF dermoscopic diagnosis K = 0.696 Teleconsultation clinical diagnosis K = 0.443 Teleconsultation dermoscopic diagnosis K = 0.450 **Correct definitive diagnosis** FTF 66% Teleconsultation 52% ($p < 0.05$)	Teledermoscopy of hypopigmented or non-pigmented lesions does not provide a similar degree of diagnostic accuracy as FTF diagnosis due to the absence of typical criteria. Dermoscopy improves the accuracy of diagnosis in FTF consultations but not in teleconsultations. **Limitations** Small sample size, absence of baseline clinical and demographic characteristics.

Table 2: Summary of Results from Non-randomized Comparative Studies Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions and Limitations**
Moreno-Ramirez et al. (2007)[15] Multicenter, longitudinal evaluation study			
To evaluate SF teledermatology for the routine triage of patients with skin cancer.	A referred sample of patients (n = 2,009) from 12 primary care centers in southern Spain were managed through teleconsultation at a pigmented lesion and skin cancer clinic. A random sample of patients (n = 403) managed through teleconsultation were referred to the FTF clinic and compared with patients routinely referred to the FTF clinic (n = 882) for diagnostic accuracy. Clinical and dermoscopical examination or histopathological results were considered the gold standards. Filtering percentage (per cent of patients not referred to FTF clinic), waiting intervals compared to those managed through the conventional letter referral system, and skin cancer detection rates following teledermatology-based triage were evaluated as effectiveness indicators. Management options were limited to "referral" or "non-referral" of patients to the FTF clinic. Intra-observer agreement was evaluated in a random sample (n = 1,589) of teleconsultations in 2 sessions 3 to 12 months apart to lower the possibility of observer bias. Inter-observer agreement	**Filtering percentage** 51.20% (95% CI 49.00% to 53.40%) **Mean waiting interval to attend clinic** SF teledermatology: 12.31 days (95% CI 8.22 to 16.40 days) Letter referral: 88.62 days (95% CI 38.42 to 138.62 days) ($p < 0.001$) **Cancer detection rates** Malignant melanoma: 1 in 49.89 patients (2.02%; 95% CI 1.10% to 2.94%) Any malignant or premalignant lesion: 1 in 3.71 patients (27.94%; 95% CI 24.98% to 30.90%) **Avoidance of unnecessary referrals** Of the patients referred to the clinic, 71.21% had cutaneous lesions that required surgical or medical therapy or periodic follow-up at the clinic. The remaining 28.79% did not require any intervention and were discharged from the clinic (unnecessary referrals). **Intra-observer agreement** Diagnosis K = 0.95 (95% CI 0.94 to 0.96) Management K = 0.91 (95% CI 0.89 to 0.93)	SF teledermatology is an effective, accurate, reliable, and valid approach suitable to be integrated into routine management of patient referrals in skin cancer and pigmented lesion clinics. **Limitations** Random subsamples of the referred population were used for reliability, accuracy, and validity assessments, which may not be representative of true patient population.

Table 2: Summary of Results from Non-randomized Comparative Studies Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions and Limitations**
	was evaluated in a random sample (n = 340) of teleconsultations. Patient series: Average age 41.53 years (95% CI 40.55 to 42.51 years), 40.9% male. FTF clinic: Average age 45.53 years (95% CI 44.11 to 46.95 years), 45.4% male.	**Inter-observer agreement** Diagnosis K = 0.85 (95% CI 0.79 to 0.91) Management K = 0.83 (95% CI 0.78 to 0.88) **Accuracy** K = 0.81 (95% CI 0.78 to 0.84) **Validity** Sensitivity 0.99 (95% CI 0.98 to 1.00) Specificity 0.62 (95% CI 0.56 to 0.69) Positive likelihood ratio 2.61 Negative likelihood ratio 0.02 (95% CI 0.01 to 0.08)	
Baba et al. (2005)[16] Diagnostic agreement			
To compare the diagnostic accuracy of SF teledermatology with SF in combination with video conferencing teledermatology.	All new patients (n = 228; 242 skin lesions) admitted to a dermatology outpatient clinic in Turkey were included. 2 teledermatologists (A and B) evaluated digital images and clinical information by the conventional SF method and gave a single diagnosis. Then each communicated with the patient via web cameras and gave a single diagnosis. New images were sent if the quality of previous ones was considered inadequate. Dermatologist A then performed an FTF examination of each patient and established the gold standard diagnosis.	**Diagnostic accuracy** SF teledermatology diagnostic accuracy of 2 teledermatologists was 81% and 75%, but was statistically significantly higher with the addition of video conferencing (90% and 82%; $p < 0.001$ for both). The addition of video conferencing statistically significantly increased diagnostic accuracy compared with SF teledermatology alone for papulosquamous lesions (60% versus 80%; $p = 0.008$ and 60% versus 73%; $p < 0.001$) and eczematous lesions (70% versus 84%; $p < 0.001$ and 52% versus 67%; $p < 0.001$).	Adding web camera video conferencing to SF teledermatology consultations enhances diagnostic accuracy and improves patient satisfaction. **Limitations** New photographs were submitted in the hybrid group, which may have biased the results. Although a variety of diagnostic methods (including potassium hydroxide testing, Wood's lamp examination, and patch tests of histopathology examination) were used by dermatologist A to

Table 2: Summary of Results from Non-randomized Comparative Studies Evaluating Teledermatology			
Objectives	**Methods**	**Outcomes**	**Author Conclusions and Limitations**
	Mean age 35 years (range 2 to 82 years), 37% male.	**Inter-observer diagnostic agreement** SF teledermatology: K = 0.71 (95% CI 0.60 to 0.82) SF teledermatology with video conferencing: K = 0.79 (95% CI 0.70 to 0.88) No significant differences between the 2 methods. **Patient satisfaction** 85% of subjects would accept teledermatology in the future; of these, 82% thought consultation should include video conferencing with web cameras.	establish the gold diagnosis, methods for blinding to prevent recall bias were not reported.

CI =confidence interval; FTF = face-to-face; GP = general practitioner; K = kappa value; LI = live interactive; mm = millimetres; NR = not reported; SF = store-and-forward; SCC = squamous cell carcinoma; UK = United Kingdom; US = United States.

Economic evaluations

The results and characteristics (including analysis type, perspective, patient population, and included costs) from two cost-effectiveness[17,18] and two cost-minimization analyses[19,20] are summarized in Table 3. A cost-effectiveness study assesses the differences in costs and the differences in effectiveness between two interventions. The results are often reported as an incremental cost-effectiveness ratio (ICER).[21] An intervention is considered to be dominant if it improves effectiveness outcomes at lower costs relative to the alternative intervention.[21] A cost-minimization analysis is performed to determine which intervention is less costly when the effectiveness of the two interventions is considered to be equivalent.[21]

Two cost-effectiveness studies found store-and-forward teledermatology to be the dominant intervention from a societal perspective compared with conventional care for the management of patients with skin cancers in Spain.[17,18] Both studies assumed a public health setting with an established telecommunications infrastructure. A sensitivity analysis in one study[17] found that teledermatology was no longer dominant when extra costs were associated with the set-up and maintenance of a communication network used exclusively for teledermatology. A sensitivity analysis was not done in the second cost-effectiveness study,[18] making it difficult to determine the robustness of the results.

One cost-minimization study found direct costs to be higher with store-and-forward teledermatology compared with conventional care for the management of patients with various dermatologic conditions.[19] When the costs for lost productivity were considered, store-and-forward teledermatology was found to be cost-saving. This study was limited by the assumption of equal effectiveness based on results from one RCT,[8] the exclusion of travel costs because of the study perspective, cost estimations partially relying on patient-reported data, and lack of a sensitivity analysis. Another cost-minimization study found live interactive teledermatology using real time video conferencing to be economically viable from the health care provider perspective for the management of various dermatologic conditions compared with conventional care.[20] The results from a sensitivity analysis indicated that, in addition to providing specialist care that would otherwise be unavailable or difficult to obtain in remote areas, teledermatology could provide competitive dermatologist compensation (US$197 an hour compared with US$153 for conventional clinics). The study made the assumption that the diagnostic quality of the two interventions was equivalent, but did not provide evidence to support this claim. Because of the study perspective, patient-related costs were not included in the analysis.

Overall, these results may not be generalizable to the specific geographic requirements and public health care funding of a Canadian setting.

Table 3: Summary of Results from Economic Evaluations of Teledermatology				
Study Parameter	**Moreno-Ramirez et al., 2009[17]**	**Ferrándiz et al., 2008[18]**	**Pak et al., 2009[19]**	**Armstrong et al., 2007[20]**
Country	Spain	Spain	United States	United States
Analysis Type	Cost-effectiveness	Cost-effectiveness	Cost-minimization	Cost-minimization
Perspective	Societal	Societal	Department of Defense	Health care provider
Patient Population	Patients with suspected skin cancers.	Patients with non-melanoma skin cancer requiring presurgical management.	Patients with various dermatologic conditions (not specified).	Patients with various dermatologic conditions (actinic keratosis, eczema, acne, or other diseases of sebaceous glands, benign neoplasm, viral infections).
Intervention	SF teledermatology versus conventional care	SF teledermatology versus conventional care	SF teledermatology versus conventional care	LI teledermatology versus conventional care
Included Costs	**Fixed Costs** Equipment (computer, digital camera). **Variable Costs** Preparation and submission of teleconsultation at primary care center, evaluation of teleconsultations by dermatologist, FTF visit at local dermatologist, FTF visit at skin cancer clinic, travel to skin cancer clinic by patient, working time lost by patient.	**Fixed Costs** Telecommunication equipment. **Variable Costs** Initial visit to primary care center, presurgical management in hospital dermatology department, presurgical patient management in primary care centre, preparation and submission of teleconsultation at primary care center, dermatologist's assessment of teleconsultation, loss of work time, transport for patients with or without impediments to travel (e.g.,	**Direct Costs** Dermatology consultation, teledermatology consultation, primary care visit, laboratory tests, laboratory preparations, procedures (including biopsies, laser therapy, UV therapy, and surgery), radiological tests, and medications. **Indirect Costs** Lost productivity cost for seeking treatment was included as a cost borne directly by the department.	Compared the costs incurred by a functional LI teledermatology clinic to the records of conventional care visits at a dermatology clinic in a large medical center. Data were collected from July 2003 to January 2005. Teledermatology technology costs (including hardware, maintenance, staff training, incremental network connection charges), facility and personnel overhead (including clinic space, office staff training, supplies), physician compensation.

Table 3: Summary of Results from Economic Evaluations of Teledermatology				
Study Parameter	**Moreno-Ramirez et al., 2009[17]**	**Ferrándiz et al., 2008[18]**	**Pak et al., 2009[19]**	**Armstrong et al., 2007[20]**
	Telecommunication cost over the intranet considered negligible and not included in the cost analysis.	bedridden patients requiring medical transport). Costs of acquiring infrastructure (telecommunications, information technology, and digital photography equipment) not included in the analysis.		
Source of Effective-ness Estimates	Non-randomized comparative study[15] Time period: March 2004 to July 2005	Non-randomized comparative pilot study[22] Time period: March 2005 to February 2006	RCT[8] Time period: 4 months	Evidence for the assumption of equal effectiveness between the 2 interventions not reported.
Results	**Average total cost per patient** SF teledermatology: €79.78 Conventional €129.37 ($p < 0.005$) **Average cost for travel per patient** SF teledermatology: €6.01 Conventional: €13.2	**Average total cost per patient** SF teledermatology: €156.4 Conventional: €278.42 **Average cost for travel (no impediments) per patient** SF teledermatology: €6.34 Conventional: €12.68	**Average direct cost per patient** SF teledermatology: US$294 Conventional: US$283 **Average lost productivity cost per patient** SF teledermatology: US$47 Conventional: US$89	**Total hourly operating costs** LI teledermatology: US$273.66 Conventional: US$346.04 Assuming that 4 patients were evaluated by teledermatology consultations each hour, the hourly reimbursement for teledermatology practice was US$487, which exceeded the hourly operating cost of US$273.66.

Table 3: Summary of Results from Economic Evaluations of Teledermatology				
Study Parameter	**Moreno-Ramirez et al., 2009[17]**	**Ferrándiz et al., 2008[18]**	**Pak et al., 2009[19]**	**Armstrong et al., 2007[20]**
	Average lost productivity cost per patient SF teledermatology: €12.6 Conventional: €27.5 Statistically significant inverse relationship between average unit cost of teleconsultation and the number of teleconsultations ($p < 0.001$). **Average waiting interval (days)** SF teledermatology: 12.31 Conventional: 88.62 **ICER** Cost-saving of €0.65 per waiting day avoided.	**Average cost for travel (with impediments) per patient** SF teledermatology: €91.19 Conventional: €182.38 **Average lost productivity cost per patient** SF teledermatology: €17.1 Conventional: €34.2 **Mean time to surgical intervention (days)** SF teledermatology: 26.10 Conventional: 60.57 **ICER** Cost-saving of €3.54 per patient per waiting day avoided. **ICER in patients with impediments to travel** Cost saving of €4.87 per patient per waiting day avoided.	**Total cost per patient:** SF teledermatology US$340 Conventional: US$372	

Table 3: Summary of Results from Economic Evaluations of Teledermatology				
Study Parameter	**Moreno-Ramirez et al., 2009[17]**	**Ferrándiz et al., 2008[18]**	**Pak et al., 2009[19]**	**Armstrong et al., 2007[20]**
		ICER in patients without impediments to travel Cost saving of €3.10 per patient per waiting day avoided.		
Sensitivity Analysis	Teledermatology remained dominant when the number of skin cancer clinic visits avoided was cut in half. Teledermatology was no longer dominant when extra costs were associated with the set-up and maintenance of a communication network used exclusively by teledermatology.	Not conducted.	Not conducted.	Three separate one-way sensitivity analyses showed that, for the cost of teledermatology consultations to equal that of conventional clinics, the cost of teledermatology could increase by 9.3-fold, dermatologists working at the teledermatology practice could be compensated up to US$197 an hour (compared with US$153 for conventional clinics), or the cost of teledermatology clinic space could reach US$57 an hour.
Author Conclusions	SF teledermatology is cost-effective for managing referrals in skin cancer clinics in a public health system equipped with an intranet.	SF teledermatology is cost-effective for remote pre-surgical planning and preparation in patients with non-melanoma skin cancer in a public health setting with an already established telecommunications infrastructure (corporate intranet).	From a Department of Defense perspective, SF teledermatology is a cost-saving strategy compared with conventional consultation when costs associated with lost productivity are considered.	From a health care provider perspective, LI teledermatology can be an economically viable means of providing dermatological care to remote areas.

FTF = face-to-face; ICER = incremental cost-effectiveness ratio; LI = live interactive; RCT = randomized controlled trial; SF = store-and-forward; US = United States; UV = ultraviolet.

Limitations

The following limitations were noted in the studies that were described in this review:

- Many of the identified studies were performed in experimental clinical settings, with investigators pre-selecting lesions for evaluation. Therefore, the results may not have been representative of routine adult dermatology referrals and teledermatology systems in clinical practice.
- Small sample size and non-diverse study populations may have limited the generalizability of some results.
- Low recruitment and high attrition rates may have limited the validity of findings from RCTs.
- The intraobserver design of some studies may have biased results in favor of teledermatology in the absence of blinding to prevent recall bias.
- One study assessed clinical outcomes. There were several limitations in the generalizability of findings to patients with different dermatologic conditions. Most studies assessed intermediate clinical outcomes such as time to clinic attendance, time to treatment, and avoidance of unnecessary referrals. It is unclear whether or not improvements in intermediate clinical outcomes results in better health outcomes.
- None of the economic studies were conducted in Canada. It is unclear whether the implementation of teledermatology services would be cost-effective based on the geographic needs and public health care funding in Canada.

5 CONCLUSIONS AND IMPLICATIONS FOR DECISION- OR POLICY-MAKING

Based on the results of recent studies, teledermatology may be beneficial for geographically isolated patients who would not otherwise be seen by a dermatologist. The largest body of research focuses on the diagnostic reliability of teledermatology. Recent evidence shows that teledermatology consultations — whether using store-and-forward, live interactive, or hybrid techniques — result in highly reliable diagnoses and management plans that compare favorably with those of conventional clinic-based care.

The evidence that store-and-forward teledermatology or teledermoscopy can be used to accurately predict disease compared to gold standard tests is conflicting. Teleconsultations were statistically significantly less accurate compared with clinic-based care in studies that used histopathology results as the reference diagnostic standard. This finding is particularly concerning in the field of skin cancer, where a misdiagnosis could lead to significant morbidity and mortality. No recent studies have assessed diagnostic accuracy when using live interactive teledermatology alone.

There is consistent evidence that teledermatology improves wait times and decreases the number of unnecessary referrals. Whether this finding translates into improved health outcomes for patients living in rural areas is unclear. Overall, patient satisfaction did not differ between groups receiving teledermatology or conventional clinic-based care. Some patients preferred the addition of video conferencing during the teleconsultation. In general, provider satisfaction was poorly reported. One study provided information on the general practitioner and teleconsultant experience with using teledermatology. The concerns that were reported by general practitioners included a process that was time-consuming, an increased workload, and the complexity of the teledermatology system. Teleconsultant concerns included a lack of patient contact and less confidence in the diagnosis made using teledermatology.

Economic evaluations found store-and-forward teledermatology to be cost saving from a societal perspective for the management of patients with skin cancer. Much of the research on the economic viability of teledermatology services has become redundant as a result of evolving technologies and changing equipment costs. It is unclear whether the implementation of teledermatology services using existing technologies would be cost-effective based on the specific geographic requirements in rural Canadian settings. There is no evidence to support the cost-effectiveness of live interactive teledermatology, although one cost-minimization analysis deemed it to be an economically viable means of providing dermatological care to remote areas.

Teledermatology appears to be a feasible alternative to conventional clinic-based care across a spectrum of dermatologic conditions. There may be indications that may be less amenable to teledermatologic care if studied as distinct entities using the same set of conditions. Larger and more comprehensive studies assessing patient outcomes such as harm resulting from missed diagnoses or incorrect treatments in different dermatologic indications will better define the value of teledermatology and guide implementation decisions.

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APPENDIX 1: LITERATURE SEARCH STRATEGY

OVERVIEW	
Interface:	Ovid SP
Databases:	EMBASE <1996 to date of search> Ovid Medline <1950 to date of search> Ovid Medline In-Process & Other Non-Indexed Citations <date of search> **Note:** Subject headings have been customized for each database. Duplicates between databases were removed in Ovid.
Date of Search:	April 6, 2010
Alerts:	Monthly search updates began April 2010 and ran until May 11, 2010.
Study Types:	No filters were applied to limit the retrieval by study type.
Limits:	English language, publication years 2005 – 2010.
SYNTAX GUIDE	
/	At the end of a phrase, searches the phrase as a subject heading
MeSH	Medical Subject Heading
Exp	Explode a subject heading
*	Before a word, indicates that the marked subject heading is a primary topic; or, after a word, a truncation symbol (wildcard) to retrieve plurals or varying endings
ADJ	Requires words are adjacent to each other (in any order)
ADJ#	Adjacency within # number of words (in any order)
.ti	Title
.ab	Abstract
.hw	Heading Word; usually includes subject headings and controlled vocabulary
.pt	Publication type
.jn	Journal name
use prmz	Limits results to the Medline database
use emef	Limits results to the EMBASE database

MULTI-DATABASE STRATEGY	
#	**Strategy**
	Teledermatology Concept
1	*teledermatology/
2	(teledermatolog* or tele-dermatolog* or telederm or tele-derm or teledermatopatholog* or teledermatopatholog* or tele-dermatopatholog* or teledermoscop* or tele-dermoscop* or teledermatoscop* or tele-dermatoscop*).ti,ab.
3	1 or 2
	Dermatology Concept
4	Dermatology/ use prmz
5	*Dermatology/ use emef
6	exp Skin diseases/ use prmz
7	exp *skin disease/ use emef
8	(dermatolog* or dermatopatholog* or dermoscop*).ti,ab,jn.
9	(skin disease* or skin patholog* or psoriasis or psoriatic or skin cancer* or skin tumour* or

MULTI-DATABASE STRATEGY	
#	**Strategy**
	skin tumor* or skin lesion*).ti,ab.
10	or/4-9
	Telemedicine Concept
11	exp Telemedicine/ use prmz
12	exp *telehealth/ use emef
13	(telehealth or tele-health or telecare or tele-care or telemedic* or tele-medic* or e-health* or ehealth*).ti,ab.
14	(remote assessment* or rural assessment*).ti,ab.
15	(telepathology or tele-pathology).ti,ab.
16	(telemonitor* or tele-monitor* or telehome* or tele-home* or telematic or tele-matic or teleconsult* or teleconsult* or telemanagement or tele-management or teleservic* or tele-servic* or telediagnos* or tele-diagnos* or teletransmi* or tele-transmi* or transtelephonic or trans-telephonic or telefax or tele-fax).ti,ab.
17	((remote or wireless or mobile) adj2 (monitor* or consult* or screening or surveillance)).ti,ab.
18	(teleconferenc* or tele-conferenc* or videoconferenc* or video conferenc* or webconference* or web conferenc* or web consult*).ti,ab.
19	(m-health* or mobile health*).ti,ab.
20	(telemed* or eHealth).jn.
21	or/11-20
	Search Results
22	3 or (10 and 21)
23	remove duplicates from 22
24	Limit 23 to English language
25	Limit 24 to yr="2005 -Current"

OTHER DATABASES	
PubMed	Same MeSH, keywords, limits, and study types used as per MEDLINE search, with appropriate syntax used.
The Cochrane Library Issue 3, 2010	Same MeSH, keywords, and date limits used as per MEDLINE search, excluding study types and human restrictions. Syntax adjusted for Cochrane Library databases.

Grey Literature

Dates for Search:	March 30, 2010 – April 7, 2010.
Keywords:	Included terms for teledermatology.
Limits:	Publication years 2005 to date of search. Conferences and meetings 2009 to date of search.

The following sections of the CADTH grey literature checklist, *Grey matters: a practical tool for evidence-based searching*, (http://www.cadth.ca/index.php/en/cadth/products/grey-matters) were searched:

- Health Technology Assessment (HTA) Agencies
- Health Economics
- Internet Search.

Conferences and Meetings

The Canadian Telehealth Forum (formerly the Canadian Society of Telehealth)
http://www.cst-sct.org/

American Telemedicine Association
http://www.americantelemed.org/

APPENDIX 2: GLOSSARY

Cost-effectiveness analysis: an analysis that compares the incremental cost and incremental effectiveness of two or more interventions. The units of effectiveness are non-monetary measures.

Cost-minimization analysis: an analysis that compares the costs of a program that achieves, or is assumed to achieve, the same outcome as the alternative method of service delivery for the purpose of identifying the lowest-cost intervention.

Diagnostic accuracy: the probability that the results of a test will accurately predict presence or absence of disease compared with a gold standard method of diagnosis.

Diagnostic reliability (agreement): the repeatability or reproducibility of an examination finding or other diagnostic assessment using the same or a different (but not the gold standard) diagnostic method. The kappa statistic is often used in diagnostic reliability assessments. A kappa value of 0.6 or higher is considered to be a substantially higher level of agreement than would be expected by chance and is accepted as a benchmark of high reliability.[23]

Incremental cost-effectiveness ratio (ICER): the ratio of the difference in costs over the difference in effectiveness outcomes for the interventions being compared.

Inter-observer reliability: reliability measured between two or more examiners.

Intra-observer reliability: reliability measured between one examiner and themselves over serial reviews, using different modalities or the same modality.

Live interactive teledermatology: a technique that uses video conferencing technology. Participants are separated by space but not by time.

Negative likelihood ratio: ratio of the proportion of patients with disease who have a negative test result (false-negative rate) to the proportion of people without disease who have a negative test result (true-negative rate or specificity).

Positive likelihood ratio: ratio of the proportion of patients with disease who have a positive test result (true-positive rate or sensitivity) to the proportion of people without the disease who have a positive test result (false-positive rate).

Sensitivity: the proportion of patients with disease who have a positive test result (true-positive).

Specificity: the proportion of patients without disease who have a negative result (true-negative).

Store-and-forward teledermatology: a technique in which asynchronous, still digital image technology is used for communication, analogous to an email system. Participants are typically separated by time and space.

Teledermoscopy: an application of teledermatology involving the use of an epiluminescence microscope to create digital dermoscopic images for the early detection of malignant skin lesions.

APPENDIX 3: SELECTION OF PUBLICATIONS