

# **Summary of the Status of Tele dermatology Research**

**Tele dermatology Special Interest Group  
American Telemedicine Association**

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## Table of Contents

Introduction .....	3
Terminology .....	4
Part 1. Diagnostic Reliability .....	5
Diagnostic Reliability – Store and Forward .....	5
Interobserver Reliability .....	5
Intraobserver Reliability .....	7
Diagnostic Reliability – Real-time Interactive .....	8
Interobserver Reliability .....	8
Intraobserver Reliability .....	9
Diagnostic Reliability – Combined Modalities .....	9
Summary .....	9
Directions for Future Research .....	10
Part 2. Management Reliability .....	10
Management Reliability – Store and Forward .....	10
Management Reliability – Real Time Interactive .....	11
Summary .....	11
Directions for Future Research .....	11
Part 3. Diagnostic Accuracy .....	12
Diagnostic Accuracy – Store and Forward .....	12
Diagnostic Accuracy – Real-time Interactive .....	14
Summary .....	14
Directions for Future Research .....	14
Part 4. Clinical Outcomes .....	14
Clinical Outcomes – Store and Forward .....	14
Clinical Outcomes – Real-time Interactive .....	16
Summary .....	17
Directions for Future Research .....	18
Part 5. Economic Analyses .....	18
Economic Analyses – Store and Forward .....	18
Economic Analyses – Real-time Interactive .....	18
Summary .....	20
Directions for Future Research .....	20
Part 6. Satisfaction Assessments .....	20
Satisfaction Assessments – Store and Forward .....	20
Patient Satisfaction .....	20
Referring Clinician Satisfaction .....	21
Consultant Satisfaction .....	22
Satisfaction Assessments – Real-time Interactive .....	23
Patient Satisfaction .....	23
Referring Clinician Satisfaction .....	24
Consultant Satisfaction .....	25
Summary .....	25
Directions for Future Research .....	25
References .....	26

## **Introduction**

The intent of this document is to serve the disciplines of research, clinical care, administration, and health policy by providing a concise review of the current status of tele dermatology research. This summary is not a detailed critique of research methodology, but rather a review of current evidence that is of sufficient quality to arrive at reasonable conclusions as of the report date.

The review is organized under major research headings that are relevant areas of investigation for tele dermatology research. These categories include (1) diagnostic reliability, (2) management reliability, (3) diagnostic accuracy, (4) clinical outcomes, (5) economic analyses, and (6) satisfaction assessments. The categories are further divided by consult modality, namely store and forward and real-time interactive. "Hybrid" models employ elements of each, specifically, a real-time interactive component coupled with high-resolution still images. A summary statement will appear at the end of each section consisting of the conclusions that can be reached based on current evidence. Finally, areas of future research needs will be identified.

## Terminology

1. ***Store and Forward*** – a telemedicine technique that uses asynchronous still digital image technology for communication, analogous to an e-mail system. Participants are typically separated by both time and space.
2. ***Real-time Interactive*** – a telemedicine technique that uses video-conferencing technology. Participants are separated only by space, not by time.
3. ***Reliability*** – the repeatability or reproducibility of an examination finding or other diagnostic assessment. It is also known as agreement or precision. Two examiners that independently reach the same diagnosis are displaying diagnostic reliability.
4. ***Interobserver Reliability*** – reliability measured between two or more different examiners.
5. ***Intraobserver Reliability*** – reliability measured between one examiner with his or her self over serial reviews either with different modalities or by the same modality.
6. ***Accuracy*** – describes whether the diagnosis offered is correct or incorrect. Typically, accuracy is evaluated using a gold standard test. The gold standard test is considered to be the best available test for classifying the presence or absence of disease.
7. ***Economic Perspective*** – a consideration of the economic impact from a specific point of view, such as, total societal costs versus cost borne only by the health care system.
8. ***Cost analysis*** – an accounting of the cost, irrespective of effectiveness or benefit, of an intervention(s).
9. ***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.
10. ***Cost-benefit analysis*** – an analysis in which both the incremental costs and the incremental benefits of two or more interventions are expressed only in monetary terms.
11. ***Cost-minimization analysis*** – an analysis that compares costs that achieve, or are assumed to achieve, the same outcome.

## Part 1. Diagnostic Reliability

### 1. Diagnostic Reliability – Store and Forward

**1a. Interobserver Reliability.** Interobserver reliability between teledermatologists and clinic-based dermatologists when using store and forward technology has ranged from 0.41 to 0.95, reported as simple proportion agreement. (1-7, 45, 46, 53, 59, 62) (Table 1)

**Table 1. Interobserver diagnostic reliability between clinic-based dermatologists and teledermatologists using store and forward technology – point estimate data reported as simple proportion agreement.**

Reference	Complete Agreement	Partial Agreement
Kvedar (1)	0.61 – 0.64	0.67 – 0.70
Zelickson (2)	0.88	---
Lyon (3)	0.89	---
High (4)	0.64 – 0.77	0.81 – 0.89
Whited (5)	0.41 – 0.55	0.79 – 0.95
Taylor (6)	0.44 – 0.51	0.57 – 0.61
Lim (7)	0.73 – 0.85	0.83 – 0.89
Eminovic (45)	0.41	0.51
Du Moulin (46)	0.54	0.63
Mahendran (53)	0.44 – 0.48	0.64 – 0.65
Oakley (59)	0.53	0.64
Tucker (60)	0.56	0.68
Bowns (62)	0.55	---

Complete Agreement – considers the single most likely diagnosis.

Partial Agreement – considers both the single most likely diagnosis and differential diagnoses or comparable diagnoses.

One study employed multiple examinations of the same patient sample to place interobserver reliability assessments in the context of a “baseline” level of agreement found among different clinic-based examiners. (5) Interobserver reliability between clinic-based examiners and teledermatologists, and between different teledermatologist pairs, was compared to the level of reliability found among different clinic-based examiners. Comparable reliability was found among all groups. (Table 2)

**Table 2. Results of the Whited, et al. study that compared multiple examiner pairings for diagnostic reliability.**

Examiner Pairings		Complete Agreement	95% CI ranges	Partial Agreement	95% CI ranges
<i>Clinic-based</i>	<i>Clinic-based</i>	<b>0.54</b>	(0.46 – 0.61)	<b>0.92</b>	(0.88 – 0.96)
<i>Clinic-based</i>	<i>Teledermatologist</i>	<b>0.41 to 0.55</b>	(0.34 – 0.63)	<b>0.83 to 0.95</b>	(0.78 – 0.98)
<i>Teledermatologist</i>	<i>Teledermatologist</i>	<b>0.49 to 0.55</b>	(0.41 – 0.63)	<b>0.84 to 0.92</b>	(0.79 – 0.96)

Complete Agreement – considers the single most likely diagnosis.

Partial Agreement – considers both the single most likely diagnosis and differential diagnoses.

A second study compared diagnostic agreement between teledermatologists examiners and two clinic-based examiners that reached their diagnoses independently. (62) This also allowed a comparison of teledermatologists-clinic-based examiner agreement with agreement found among clinic-based examiners. In this case a significant difference was found for these pairings. The level of agreement found among two clinic-based examiners (0.78) was significantly higher than that found between teledermatologists and clinic-based examiners (0.55),  $p = 0.002$ . However, there were recruitment, randomization, and in-person assessment delay issues that prompted the authors to conclude that no valid statistical conclusions should be drawn from these results.

The kappa statistic is a chance-corrected measure of agreement. Although somewhat arbitrary, a kappa of 0.61 or higher is considered a substantially higher level of agreement than would be expected by chance alone, and is generally accepted as a benchmark of high reliability. (19) Five studies have analyzed reliability using the kappa statistic. Analysis with the kappa statistic requires categorical data. One study categorized the data based on whether the examiners considered a lesion to represent a benign or malignant condition and the others used lesion categories that included benign and malignant presentations. (5, 9, 56, 57, 64) (Table 3)

**Table 3. Diagnostic reliability measures using the kappa statistic.**

<b>Reference</b>	<b>Lesion Category</b>	<b>Agreement Category</b>	<b>Examiner Pairings</b>	<b>Kappa</b>	<b>95% CI ranges</b>
Whited (5)	Malignancy	Complete	<i>Clinic-based vs. clinic-based</i>	<b>0.68</b>	0.52 – 0.83
Whited (5)	Malignancy	Complete	<i>Teledermatologist vs. teledermatologist</i>	<b>0.68</b>	0.59 – 0.77
Whited (5)	Malignancy	Partial	<i>Clinic-based vs. clinic-based</i>	<b>0.77</b>	0.62 – 0.92
Whited (5)	Malignancy	Partial	<i>Teledermatologist vs. teledermatologist</i>	<b>0.63</b>	0.55 – 0.72
Krupinski (9)	Various Lesion Types	Partial	<i>Clinic-based vs. teledermatologist</i>	<b>0.80 to 0.82</b>	---
Baba (56)	Various Lesion Types	Complete	<i>Teledermatologist vs. teledermatologist</i>	<b>0.71</b>	0.60 – 0.82
Moreno-Ramirez (57)	Various Lesion Types	Complete	<i>Teledermatologist vs. teledermatologist</i>	<b>0.91</b>	0.87 – 0.96
Moreno-Ramirez (57)	Various Lesion Types	Complete	<i>Clinic-based vs. teledermatologist</i>	<b>0.90</b>	0.90 – 1.0
Moreno-Ramirez (64)	Various Lesion Types (5 categories)	Complete	<i>Teledermatologist vs. teledermatologist</i>	<b>0.85</b>	0.79 – 0.91

Complete Agreement – considers the single most likely diagnosis/category.

Partial Agreement – considers both the single most likely diagnosis and differential diagnoses.

**1b. Intraobserver Reliability.** Table 4 summarizes studies of intraobserver agreement measured between the same examiner reviewing a patient in a clinic setting versus their review of that patient’s teledermatology consultation.

**Table 4. Intraobserver diagnostic reliability between clinic-based evaluations and store and forward teledermatology evaluations – point estimate data reported as simple proportion agreement.**

Reference	Complete Agreement	Partial Agreement
Taylor (6)	0.31 – 0.64	0.50 – 0.70
Lim (7)	0.88	0.95
Pak (8)	0.70	0.91
Krupinski (9)	---	0.76 – 0.90

Complete Agreement – considers the single most likely diagnosis.

Partial Agreement – considers both the single most likely diagnosis and differential diagnoses.

Intraobserver agreement among the same examiners conducting serial reviews of teledermatology consultations was found to be high (kappa 0.93, 95% CI 0.87-0.98). (57)

## 2. Diagnostic Reliability – Real-time Interactive.

**2a. Interobserver Reliability.** Interobserver agreement between teledermatologists and clinic-based dermatologists when using real-time interactive technology has ranged from 0.54 – 0.99, reported as simple proportion agreement. (10-16) Table 5 summarizes the point estimate data from these studies.

**Table 5. Interobserver diagnostic reliability between clinic-based dermatologists and teledermatologists using real-time interactive technology – point estimate data reported as simple proportion agreement.**

	Complete Agreement	Partial Agreement
Leshner (10)	0.78	0.99
Gilmour (11)	0.54	0.80
Lowitt (12)	0.80	---
Loane (13)	0.60	0.76
Phillips (14)	0.77	---
Phillips (15)	0.59	---
Nordal (16)	0.72	0.86

Complete Agreement – considers the single most likely diagnosis.

Partial Agreement – considers both the single most likely diagnosis and differential diagnoses.

One of these studies (10) also measured the level interobserver agreement found between two clinic-based examiners to provide a context for the level of inter-modality reliability. Like the store and forward study (5), a comparable level of agreement was found between examiner pairings. (Table 6)

**Table 6. Results of the Lesher, et al. study that compared multiple examiner pairings for diagnostic reliability.**

Examiner Pairings		Complete Agreement	95% CI range	Partial Agreement	95% CI range
<i>Clinic-based</i>	<i>Clinic-based</i>	<b>0.94</b>	(0.87 – 1.0)	<b>1.0</b>	---
<i>Clinic-based</i>	<i>Teledermatologist</i>	<b>0.78</b>	(0.68 – 0.88)	<b>0.99</b>	(0.97 – 1.0)

Complete Agreement – considers the single most likely diagnosis.

Partial Agreement – considers both the single most likely diagnosis and differential diagnoses.

**2b. Intraobserver Reliability.** The two studies that have reported intraobserver agreement among clinic-based examiners and teledermatologists are shown in Table 7.

**Table 7. Intraobserver diagnostic reliability between clinic-based dermatologists and teledermatologists – point estimate data reported as simple proportion agreement.**

	Complete Agreement	Partial Agreement
Gilmour (11)	0.59	0.76
Loane (13)	0.71	0.87

Complete Agreement – considers the single most likely diagnosis.

Partial Agreement – considers both the single most likely diagnosis and differential diagnoses.

Intraobserver agreement for a teledermatologist was found to be 0.95 (95% CI 0.94-0.96) in one study. (64)

### **3. Diagnostic Reliability – Combined Modalities.**

One study evaluated the incremental effect of using videoconferencing in addition to an initial store and forward teledermatology consultation. (56) Both intraobserver and interobserver agreement with an in-person evaluation showed statistically significant increases when videoconferencing was used in combination with a store and forward consultation compared to store and forward as the sole modality. Intraobserver simple agreement increased from 0.81 to 0.90 ( $p < 0.001$ ) and interobserver simple agreement increased from 0.75 to 0.82 ( $p < 0.001$ ).

**Summary:** The largest and strongest body of research exists regarding the diagnostic reliability of teledermatology. The evidence shows that teledermatology consultations, whether using store and forward or real-time interactive techniques, result in highly reliable diagnoses that compare favorably with conventional clinic-based care. This conclusion is based on the repeatability of high simple proportion agreement found in multiple research studies, studies that made simultaneous assessments of “baseline”

reliability found among different clinic-based examiners, and reports that used chance-corrected measures of agreement.

**Directions for Future Research:** Research into diagnostic reliability is fairly comprehensive. Additional studies that simultaneously assess “baseline” agreement among different clinic-based examiners with teledermatologist pairings would serve to confirm the findings of the two existing studies that have found comparable reliability. (5, 10)

## Part 2. Management Reliability

**1a. Management Reliability – Store and Forward.** Five studies have assessed the reliability of biopsy or operative recommendations between a teledermatologist and an in-person dermatologist and are presented in Table 8.

**Table 8. Interobserver agreement between clinic-based evaluations and teledermatologists for biopsy or operative recommendations.**

	Simple Agreement	Kappa	95% CI Range for Kappa
Pak (48)	0.76	0.47	0.39 – 0.56
Shapiro (49)	1.0	1.0	0.72 – 1.0
Whited (18)	0.90 – 1.0	---	---
Oakley (59)*	0.82	---	---
Ferrandiz (67)**		0.75	0.71 – 0.79

\* includes recommendations to “biopsy” or “excise”

\*\* agreement on surgical technique

A randomized clinical trial found that management recommendations differed between teledermatologists-clinic-based examiner pairings and two different clinic-based examiners. (62) Teledermatologists agreed with a clinic-based examiner 55% of the time compared to agreement between two different clinic-based examiners of 84%,  $p = 0.0001$ . However, there were recruitment, randomization, and in-person assessment delay issues that prompted the authors to conclude that no valid statistical conclusions should be drawn from these results.

One study compared three different categories of management recommendations between different clinic-based examiners, clinic-based examiners and teledermatologists, and different teledermatologists examiners. (5) For medical therapy recommendations, all three groups showed comparable reliability. Clinic-based therapy recommendations showed less reliability than medical therapy recommendations, but were still largely reliable. Diagnostic testing recommendations, which included biopsy decisions, were not reliable. Another study found that the management plan of the clinic-based dermatologist agreed with the teledermatologist in 90% of the cases. (2) Among 43% (70/163) of patients referred for minor operations (including biopsies) after a teledermatology

consult, 54 of those (77%) were considered appropriately referred when compared to the results of the conventional clinic-based visit. (53) The remaining 16 (23%) were considered inappropriately referred based on: (a) referral for the wrong procedure, (b) a procedure was not required, or (c) a more complex intervention was required. Another study found a kappa of 0.92 (95% CI 0.86-0.98) among different teledermatologist examiners for agreement among the need for referral for a clinic-based visit. (57) A larger series of patients from this study design yielded a kappa of 0.83 (95% CI 0.78-0.88) for interobserver agreement among teledermatologists and 0.91 (95% CI 0.89-0.93) for intraobserver agreement. (64) In yet another study the overall agreement for management plans between teledermatologists and in-person dermatologists was 36%. (59)

**1a. Management Reliability – Real Time Interactive.** One study that assessed the reliability of biopsy recommendations between a teledermatologist and an in-person dermatologist is presented in Table 9.

**Table 9. Interobserver agreement between clinic-based evaluations and teledermatologists for biopsy recommendations.**

	Simple Agreement	Kappa	95% CI Range for Kappa
Phillips (15)	0.86	0.47	0.24 – 0.71

One study that assessed agreement by categories of treatment plans between a teledermatologist and a clinic-based dermatologist found agreement in 72% of cases. (11) In another study, the management plan was rated to be the same or similar in 64% of cases. (50) Of note, in 19% of the cases the teledermatologist could not arrive at management plan.

**Summary:** High simple agreement has been found for biopsy decisions made by teledermatologists and clinic-based dermatologists when using both store and forward and real time interactive techniques. Using kappa statistics, the strength of agreement has ranged from moderate to perfect. Management reliability is arguably of secondary importance to diagnostic reliability, due to variation in treatment preferences found among dermatologists. Management of skin conditions is an intermediary step linking a diagnosis with a clinical outcome. A management strategy, in and of itself, does not necessarily predict a clinical outcome.

**Directions for Future Research:** Future studies that more completely describe management recommendation reliability would add to the current body of evidence that has largely focused on biopsy recommendations. Because of the aforementioned limitations of management reliability research, correlating reliability data with processes of care, clinical outcomes, and economic outcomes would be most useful additions to the current body of research.

## **Part 3. Diagnostic Accuracy**

Diagnostic accuracy assessments for dermatologic disease are somewhat problematic. Histopathologic review of biopsied tissue functions as a gold standard, however, its primary utility in accuracy assessments is for determining the presence or absence of malignancy. Histopathologic review cannot be universally used to make a definitive diagnosis of all skin lesions. Therefore, diagnostic accuracy assessments of dermatologic conditions are somewhat constrained. In some cases, authors have used clinic-based dermatologists' findings as a pragmatic gold standard. For this document those studies are detailed in the diagnostic reliability section above.

### **1. Diagnostic Accuracy – Store and Forward**

Studies that report diagnostic accuracy appear in Table 10. Four studies that analyzed data among a subset of patients that underwent a biopsy and/or had other reference standard tests (e.g., KOH preparation) found comparable diagnostic accuracy between clinic-based examiners and teledermatologists (5, 9, 57, 59) whereas another study found higher accuracy rates among teledermatologists. (66) Less conclusive studies correlated histopathologic review with traditional photographs and referral letters (17) and analyzed a very small sample size (18).

**Table 10. Diagnostic accuracy rates by consult modality.**

<b>Reference</b>	<b>Modality</b>	<b>Complete Accuracy Rate</b>	<b>95% CI ranges</b>	<b>Partial Accuracy Rate</b>	<b>95% CI ranges</b>
Whited (5)	<i>Clinic-based</i>	<b>0.59 - 0.71</b>	0.48 – 0.81	<b>0.85</b>	0.77 – 0.93
	<i>Teledermatology</i>	<b>0.53 - 0.63</b>	0.42 – 0.74	<b>0.68 – 0.85</b>	0.58 – 0.93
Krupinski (9)	<i>Clinic-based</i>	---	---	<b>0.80 – 0.97</b>	---
	<i>Teledermatology</i>	---	---	<b>0.73 – 0.78</b>	---
Harrison (17)	<i>Clinic-based</i>	---	---	---	---
	<i>Teledermatology</i>	<b>0.71</b>	---	---	---
Whited (18)	<i>Clinic-based</i>	<b>0.70 - 0.77</b>	---	<b>0.80 – 0.92</b>	---
	<i>Teledermatology</i>	<b>0.31 - 0.85</b>	---	<b>0.85</b>	---
Moreno-Ramirez (57)	<i>Teledermatology</i>	<b>0.79</b>	---	---	---
Oakley (59)	<i>Clinic-based</i>	<b>0.72</b>	0.53-0.87	---	---
	<i>Teledermatology</i>	<b>0.71</b>	0.56-0.83	---	---
Lozzi (66)	<i>Clinic based</i>	<b>0.30-0.42</b>	0.15-0.53	---	---
	<i>Teledermatology</i>	<b>0.79</b>	0.72-0.93	---	---

Complete Accuracy – accuracy based on the single most likely diagnosis.

Partial Accuracy – accuracy based on single most likely and differential diagnoses.

In the study by Lozzi, et al (66) the gold standard included histopathologic diagnosis in all 33 cases combined with a clinical assessment made at a follow-up in-person examination. The teledermatology assessment included the ability for the teledermatologist to consult with other teledermatologists and to request additional information from the in-person dermatologists. In this setting teledermatology yielded significantly higher accuracy rates than did in-person examinations.

One additional study combined histopathologic diagnosis with clinical consensus among three dermatologists (that rated their diagnosis with high confidence) as dual gold standards. (64) An important feature of this study was that it assessed a random subsample of clinically suspect malignant and benign lesions, allowing for an evaluation of sensitivity and specificity. Accuracy was based on whether a diagnosis was considered "positive" or "negative" for malignancy. Sensitivity for teledermatology was high 0.99 (95% CI 0.98-1.0) whereas specificity was lower 0.62 (95% CI 0.56-0.69).

Another study used a reliability measure (kappa) to describe agreement between the teledermatology diagnosis and histopathological diagnosis. (67) The kappa was 0.86 (95% CI , 0/83 – 0.89). Eighty-eight basal cell carcinomas were diagnosed clinically and

74 were biopsy-proven; 12 squamous cell carcinomas were diagnosed clinically and 14 were biopsy-proven.

## **2. Diagnostic Accuracy – Real-time Interactive**

To date, no studies have been published that make accuracy assessments of diagnoses provided through real-time interactive consult methods other than those that have used the pragmatic reference standard of a clinic-based dermatologists' diagnoses. Those studies appear in the diagnostic reliability section.

**Summary:** No information is available on the diagnostic accuracy of teledermatology when using real-time interactive technology. Existing evidence shows that store and forward teledermatology results in comparable diagnostic accuracy when compared to conventional clinic-based care. This is based primarily on four studies that found comparable diagnostic accuracy between teledermatologists and clinic-based examiners using histopathologic review of biopsied tissue or other reference standard tests to make these assessments (5, 9, 57, 59) and one study that found superiority with teledermatology. (66) Other studies, some less rigorous, found similar point estimate accuracy rates.

**Directions for Future Research:** Because of the lack of a gold standard test that can be universally applied across the scope of dermatologic disease, assessments of diagnostic reliability arguably take on a greater importance than diagnostic accuracy. Nonetheless, assessments of diagnostic accuracy when using real-time interactive technology are absent from the literature and additional accuracy studies when using store and forward technology would be useful to determine whether the existing data is reproducible. Studies that assess the ability of examiners to dichotomize lesions into benign versus malignant skin conditions, for which histopathologic review can act as a gold standard, should be emphasized in future accuracy studies.

## **Part 4. Clinical Outcomes**

Most published studies to date have evaluated only intermediate clinical outcomes such as consults avoided, time to intervention, and consult-related logistical issues including consult time requirements. However, one large randomized trial has been published that makes an assessment of a definitive clinical endpoint, in this case, clinical course. (61) No other studies have evaluated clinical course, have used disease-specific instruments to rate clinical status, or measured quality of life.

### **1. Clinical Outcomes – Store and Forward**

A randomized trial has been published that made an assessment of clinical course between patients undergoing a teledermatology consultation and those undergoing the conventional clinic-based consult process. (61) A dermatologist, blinded to the randomization assignment, made an assessment of the clinical course of the referred skin

conditions between baseline and 4 months. Skin conditions were rated as “improved,” “no change,” and “worse.” Table 11 shows the results of this analysis. There was no evidence to suggest that a difference existed in the clinical course experienced by patients undergoing the two examination modalities,  $p = 0.57$ .

**Table 11. Clinical course ratings from baseline to four months by examination modality as reported in the Pak, et al. study.**

	Clinical Course Rating		
	Improved	No Change	Worse
Usual Care (n = 236)	65%	32%	3%
Teledermatology (n = 272)	64%	33%	4%

One small study made a retrospective assessment of the clinical course of 50 patients who were managed with clinic visits and 50 patients who were managed with store and forward teledermatology. (51) Data for rating the clinical course was only available for 7 patients – 3 teledermatology patients and 4 usual care patients. All 3 of the teledermatology patients were rated as “improved” and 3 of the 4 usual care patients were rate as “improved” with one rated as “unchanged.”

Eleven studies have evaluated the proportion of store and forward teledermatology consults that did avoid (or would have avoided) a clinic visit to a dermatologist. (Table 12) One of these studies used traditional photographs appended to a referral letter as the “teledermatology” consultation. (20) The study by Taylor et al., also demonstrated the potential utility of teledermatology as a triage tool indicating that only 32% of the teledermatology referrals would have been scheduled for an urgent clinic consultation compared with 64% by the conventional consult process. (6)

**Table 12. Dermatology clinic visits avoided with store and forward teledermatology.**

Reference	Dermatology Clinic Visits Avoided
Loane (20)	31% (30/96)
Taylor (6)	31% (118/376)
White (21)	25% (10/40)
Whited (22)	18.5% (25/135)
Eminovic (45)	42% (40/96)
Mahendran (53)	13% (21/163)
Moreno-Ramirez (57)	51% (111/219)
Moreno-Ramirez (64)	51% (1029/2009)
Knol (58)	53% (163/306)
Bowns (62)	58% (53/92)
Martinez-Garcia (65)	42%

An outcome, although still intermediate, that is more closely linked to a patient's clinical course is the time to intervention or initial definitive contact with a dermatologist. A randomized trial compared time to intervention between patients undergoing store and forward teledermatology consults and a conventional clinic-based consult process. (22) Time to intervention was defined as the time from referral to clinic visit (if a visit was required) or time from referral to the date the consult was answered (if a clinic visit was not required). Patients undergoing store and forward teledermatology consultations reached a point of intervention significantly sooner than did patients undergoing the conventional referral process – median of 41 days versus 127 days, respectively. Another study found that teledermatology referrals that required a dermatology clinic visit were seen on average in 12 days compared to an average of 88 days for the conventional (letter) referral process. (64) This was thought to be due to faster communications with telemedicine and the avoidance of unnecessary dermatology visits (e.g., triage outcomes). Another study found that store and forward consults were answered on average in 2.17 days that compared to an average 90 day wait for a clinic-based appointment in the university setting and an average 17.18 day wait in the local community. (23) A third study found that teledermatology decreased the time it took for the referring clinician to receive an opinion about the referred patient. (62). For teledermatology this time averaged 13 days compared to 67 days for the conventional care group. Another study evaluated patients that were determined to need a biopsy or other operative procedure. (67) Teledermatology patients were operated on in a mean of 26.10 days (95% CI, 24.51 – 27.70) compared to a mean of 60.57 days (95% CI, 56.20 – 64.93) for the conventional referral system. Additionally, this study found that cancellation rates for surgery were significantly lower after a teledermatology consultation compared to the conventional referral process; 2.99% (95% CI, 1.52% - 4.46%) and 8.85% (95% CI, 5.62% - 11.81%) respectively.

Two studies assessed the time required by dermatologists to review a teledermatology consult. A study by van den Akker et al., found that it took dermatologists a median of 10 minutes to review a store and forward teledermatology consult. (27) A study by Whited et al., found that dermatologists required an average of 7.2 minutes to review a store and forward teledermatology consult compared to 24.4 minutes for clinic-based visits. (28)

## **2. Clinical Outcomes – Real-time Interactive**

One study made an assessment of clinical improvement among patients undergoing real-time interactive teledermatology consultations. (55) The outcomes of patients who underwent two teledermatology consults were retrospectively reviewed. Of 127 subjects reviewed, 74 (58.3%) were rated as showing “clinical improvement,” 21 (16.5%) were rated as showing “no clinical improvement,” 9 (7.1%) were rated “not compliant,” and 23 (18.1%) were rated “not applicable.” Not applicable implied the patient had a chronic condition that would not be expected to change. The study did not include a control group of patients undergoing conventional clinic-based consults.

Five studies have evaluated the proportion of real-time interactive teledermatology consults that avoided a clinic-based visit to a dermatologist. (Table 13)

**Table 13. Dermatology clinic visits avoided with real-time interactive teledermatology.**

Reference	Dermatology Clinic Visits Avoided
Loane (20)	55% (53/96)
Loane (24)	44.4% (56/126)
Wootton (25)	54% (55/102)
Lamminen (26)	72% (18/25)
Granlund (44)	82% (18/22)

Three studies evaluated the time required to perform real-time interactive consultations from both the patients' and dermatologists' perspectives and assessed the distances traveled by patients using teledermatology compared to conventional clinic-based care. These results are summarized in Table 14.

**Table 14. Time study and travel distance data for real-time interactive teledermatology consultations.**

Reference	Total Time (minutes)*		Distance traveled (km)		Dermatologist consult time (minutes)	
	<i>Real-time</i>	<i>Clinic-based</i>	<i>Real-time</i>	<i>Clinic-based</i>	<i>Real-time</i>	<i>Clinic-based</i>
Loane (29)	59.3	84.4	10.4	25.4	22.0	16.8
Oakley (30)	51	259	12.1	271	23	23
Loane (31)	52.59	259.18	12.6	267.1	20.04	21.60

\*Total time included waiting time, actual consult time, and travel time.

**Summary:** Clinical outcomes are the least researched areas of teledermatology. To date, only one large study has been published that assessed a definitive clinical endpoint finding no evidence to suggest a difference in the clinical course that patients experience when undergoing store and forward teledermatology consultations compared to clinic-based care. Assessments of intermediate outcomes when using store and forward teledermatology have shown that approximately 3 in 10 teledermatology consults do not require a clinic-based visit in settings where clinic-based care was normally available. Additionally, patients do reach a point of intervention with a dermatologist much sooner with store and forward teledermatology compared to the conventional referral process. A greater proportion of real-time interactive consultations avoid the need for a clinic-based evaluation (approximately 50%), however, time requirements to perform these consultations are similar to the time required to perform clinic-based evaluations. No

studies exist that evaluate time to intervention endpoints with real-time interactive technology.

**Directions for Future Research:** Clinical outcomes that assess a definitive clinical endpoint are the most vital area to target for future teledermatology research. Future studies that confirm or refute the findings of the Pak, et al., study that suggest equivalent clinical outcomes are achieved when store and forward teledermatology is used are necessary. Similarly, an assessment of the clinical outcomes of patients undergoing real-time interactive consults should be performed.

## **Part 5. Economic Analyses**

Interpretation of economic analyses depends on two main factors. The first is the type of economic analysis undertaken, i.e., cost-effectiveness analysis, cost-benefit analysis, etc. The second is the economic perspective taken by the analysis. In general, the societal economic perspective is considered the most relevant since it is an attempt to account for all the costs and outcomes encountered with an intervention. However, payers of healthcare services, such as government agencies and managed care organizations, are often interested in their own perspective. Expenditures that their organizations incur may be of greater interest to them than those costs that accrue, for example, by patients or employers for loss of work, productivity, or travel. Thus, assessments of perspectives other than a societal perspective are also important.

### **1. Economic Analyses – Store and Forward**

Very little information is available regarding the economic impact of store and forward teledermatology. A study by Whited, et al., found that, from the Department of Veterans Affairs perspective, store and forward teledermatology was the more costly alternative costing an average of \$36.40 per teledermatology patient compared to \$21.40 for patients undergoing conventional consults. (28) However, when the societal economic perspective was taken, store and forward teledermatology did become a cost saving strategy. In addition, store and forward teledermatology was found to be a very cost-effective strategy for the Department of Veterans Affairs, costing only an additional \$0.17 per patient per day of time to intervention saved. A study by Zelicson, et al., suggested that store and forward teledermatology would be a cost saving strategy when used in a nursing home facility although a formal cost-effectiveness analysis was not performed. (2)

### **2. Economic Analyses – Real-time Interactive**

Several well-designed studies have assessed the economic impact of real-time interactive teledermatology consult systems and are summarized in Table 15.

**Table 15. Economic analyses of real-time interactive consult modalities.**

Reference	Analysis	Consult Cost by Modality		Perspective	Setting
		<i>Real-time</i>	<i>Conventional Care</i>		
Wootton (25)	Cost-benefit	132.10 British pounds (per patient)	48.73 British pounds (per patient)	Societal	Community Care
Loane (24)	Cost-benefit	146.48 British pounds (per patient)	47.3 British pounds (per patient)	Societal	Urban Community Care
Loane (24)	Cost-benefit	180.22 British pounds (per patient)	48.77 British pounds (per patient)	Societal	Rural Community Care
Lamminen (26)	Cost	18,627 FM (total cost)	18,034 FM (total cost)	Societal	Community Care
Bergmo (33)	Cost-minimization	NKr 470,780 (total cost)	NKr 635,075 (total cost)	Health care sector	Community Care
Loane (31)	Cost-minimization	279.23 NZ\$ (per patient)	283.70 NZ\$ (per patient)	Societal	Rural Community Care
Chan (34)	Cost	57.7 HK\$	322.8 HK\$	Health care sector	Institutionalized patients
Persaud (54)	Cost-minimization	\$619.02 - \$4,163.09 Canadian (per patient)	---*	Societal	Community Care
Armstrong (63)	Cost-minimization	\$274 hourly operating cost	\$346 hourly operating cost	Health care sector	Community Care

\*Average costs for conventional care not reported. Total costs for real-time consults (that included psychiatry consults) ranged from \$1,736 – \$28,084 Canadian and for conventional care ranged from \$325 - \$1,133 Canadian.

An additional study that used economic modeling by Lamminen et al., found that real-time interactive teledermatology could be cost saving, but was volume dependent. (32) This study, and the above table, illustrates the point that various factors, such as the economic perspective or setting and other patient-related factors often influence the economic outcome.

**Summary:** The economic impact of store and forward teledermatology is inconclusive. Much more research has been performed on real-time interactive technology with mixed results. Typically, real-time interactive technology is more costly than conventional care, with several well-designed studies supporting this conclusion. However, in some settings it incurs equivalent costs or even results in cost savings.

**Directions for Future Research:** Additional studies on the economic impact of store and forward teledermatology are warranted. The fixed and variable costs associated with store and forward teledermatology are usually lower than real-time interactive technology, but whether that cost advantage translates into store and forward teledermatology becoming a cost saving modality compared to conventional care is largely unknown.

## **Part 6. Satisfaction Assessments**

### **1. Satisfaction Assessments – Store and Forward**

Reliable and validated instruments to assess satisfaction among participants of teledermatology consults do not exist. The existing research primarily consists of proprietary scales that are largely anecdotal but do display some face validity.

#### **1a. Patient Satisfaction.**

The major findings and themes that arise from the literature on patient satisfaction with store and forward technology appear in Table 16. In the study by Williams, et al., patients were ambivalent about whether they were more comfortable using teledermatology versus a clinic visit – 40% were more comfortable with clinic visits, 42% were more comfortable with teledermatology, and 18% were neutral. (38) Likewise, in a study by Collins et al., 38% of patients preferred in-person evaluations, 32% preferred teledermatology, and 30% were unsure. (42) An additional study found that 41.5% of subjects would rather have a teledermatology consultation, 22% were neutral, and 36.5% preferred an in-person visit. (52)

<b>Table 16. Major findings from store and forward patient satisfaction assessments.</b>			
<b>Reference</b>	<b>Positive Features and Comments</b>	<b>Negative Features and Comments</b>	<b>Overall Satisfaction</b>
Weinstock (35)	75% of respondents would recommend teledermatology	Long waiting times before learning of consult results	42%
Pak (36)	39% believed teledermatology saved time	Lack of follow-up after the consult	64%
Kvedar (37)	Satisfied that concerns were addressed	---	4.56 on a 5 point scale
van den Akker (27)	Comfortable with using digital images	Concerned about incomplete information being transmitted via teledermatology	7.4 on a 10 point scale
Williams (38)	86% were satisfied with the convenience of teledermatology	30% expressed discomfort with not speaking to a dermatologist	93%
Collins (42)	85% would be happy to use teledermatology again and 78% were satisfied with the general practitioner providing the results/treatment of the consult	40% felt something was missing by not seeing a dermatologist in-person	76%
Whited (52)	84% had confidence that the dermatologist could help them by looking at images	20% rated the time required to be informed of the consult outcome as fair or poor	82%
Bowns (62)	76% would rather be managed by teledermatology than to have to wait several weeks for a clinic appointment	40% felt something important was missing if they did not see an in-person dermatologist	81%

### **1b. Referring Clinician Satisfaction.**

The major findings and themes that arise from the literature on referring clinician satisfaction with store and forward technology appear in Table 17. In studies by Collins

et al., and Bowns et al., referring clinicians did not have favorable opinions of teledermatology. (43) Of note, the referring clinicians in these studies were required to generate and send the teledermatology consults.

<b>Table 17. Major findings from store and forward referring clinician satisfaction assessments.</b>			
<b>Reference</b>	<b>Positive Features and Comments</b>	<b>Negative Features and Comments</b>	<b>Overall Satisfaction</b>
Weinstock (35)	74% would recommend teledermatology	Consult process took too long and the backlog was too great	63%
Pak (36)	Believed they received an educational benefit	---	---
Kvedar (37)	Would like to continue using teledermatology and found it convenient	Time requirements to generate the teledermatology consult	---
van den Akker (27)	Believed they received an educational benefit	---	---
Collins (43)	Improved access to experts	Time consuming referral process, increased workload, 23% would consider using teledermatology in the future	21%
Whited (52)	84% preferred teledermatology to the conventional consult process	---	92%
Bowns (62)	60% expressed aspects of teledermatology they liked	Time consuming process, increased workload, complex teledermatology system	21%
Lavanya (68)*	100% rated the system as either convenient or somewhat convenient to use	60% rated teledermatology as not as good as conventional care	80%

\*Referring clinicians were nurses

### **1c. Consultant Satisfaction.**

Those studies that have made assessments of dermatologist consultants' satisfaction appear in Table 18.

**Table 18. Major findings from store and forward consultant satisfaction assessments.**

<b>Reference</b>	<b>Positive Features and Comments</b>	<b>Negative Features and Comments</b>	<b>Overall Satisfaction</b>
Pak (36)	70% believed that the consult was of sufficient quality to make a diagnosis	Clinic visits would have made them more confident of the diagnosis	---
van den Akker (27)	Image quality was good	---	---
Whited (52)	100% stated that triage was easier	75% were less confident in their diagnoses and management plans	75%
Bowns (62)	Teledermatology system was easy to use	Lack of patient contact, less confident in diagnoses	---

## **2. Satisfaction Assessments – Real-time Interactive**

### **2a. Patient Satisfaction.**

The major findings from the literature on patient satisfaction with real-time interactive technology appear in Table 19. As with store and forward consults, patients expressed no strong preference for usual care versus teledermatology. (11, 16, 40)

<b>Table 19. Major findings from real-time interactive patient satisfaction assessments.</b>			
<b>Reference</b>	<b>Positive Features and Comments</b>	<b>Negative Features and Comments</b>	<b>Overall Satisfaction</b>
Reid (39)	Teledermatology is of value to patients and the community	---	---
Nordal (16)	Overall, reported that features of teledermatology were as good or better than clinic-based care	14% report lack of hands-on examination a disadvantage	---
Loane (40)	66% reported that teledermatology was as good as clinic-based care	13% expressed discomfort because of the camera	---
Gilmour (11)	59% believed teledermatology was just as good as clinic-based care	18% expressed discomfort with the camera	---
Hicks (47)	Only 3% rated teledermatology as “not as good” as a clinic visit	---	88%

## **2b. Referring Clinician Satisfaction.**

Referring clinician satisfaction assessments when using real-time interactive technology appear in Table 20.

**Table 20. Major findings from real-time interactive referring clinician satisfaction assessments.**

<b>Reference</b>	<b>Positive Features and Comments</b>	<b>Negative Features and Comments</b>	<b>Overall Satisfaction</b>
Jones (41)	Positive educational benefit	Consults were time consuming	---
Gilmour (11)	Positive educational benefit	Some problems with sound and visual quality reported	---

## 2c. Consultant Satisfaction.

Satisfaction among dermatologist consultants using real-time interactive technology appears in Table 21.

**Table 21. Major findings from real-time interactive consultant satisfaction assessments.**

Reference	Positive Features and Comments	Negative Features and Comments	Overall Satisfaction
Lowitt (12)	98% believed good rapport with patients was achieved	Expressed greater confidence in clinic-based diagnoses	---
Nordal (16)	80% believed the teledermatology examination was as thorough as clinic-based care	Expressed better contact with patient with in-person examinations.	---

**Summary:** Although patient and clinician satisfaction data are anecdotal, some themes have begun to emerge from the literature. Overall, patients are satisfied with receiving dermatologic care with either consult modality. Long waits for follow-up, or even lack of follow-up, have been the biggest problems identified with store and forward consults. Patients have expressed ambivalence about a preference for teledermatology versus usual care, suggesting that they perceive these options to be equivalently acceptable means of obtaining dermatologic care. For referring clinicians, the educational benefit they perceive as a result of the consult process is the most commonly mentioned positive feature. Time constraints involved with consult generation with both modalities is frequently mentioned as a negative aspect. Fewer studies have made assessments of the dermatologist consultants' perceptions. Overall, dermatologists have been satisfied with the consult process, but report greater confidence when making diagnoses through clinic-based visits.

**Directions for Future Research:** Development of a reliable and validated instrument that can be used to assess satisfaction among both patients and clinicians is the most pressing need for the future. Existing studies have identified some recurring themes and issues that would serve as a very useful foundation for formal instrument development.

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