

Summary of the Status of Teledermatology Research

**Teledermatology Special Interest Group
American Telemedicine Association**

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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 teledermatology research. This summary is not a detailed critique of research methodology nor is it a comprehensive compendium of all teledermatology and teledermatology-related research. Rather, it is a review of current evidence by content category 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 teledermatology research. These categories include (1) diagnostic reliability, (2) management reliability, (3) diagnostic accuracy, (4) clinical outcomes, (5) quality of life, (6) economic analyses, and (7) 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 may 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 (Live) Interactive** – a telemedicine technique that uses video-conferencing technology. Participants are separated only by space, not by time.
3. **Hybrid** – a telemedicine technique that combines store and forward and real-time (live) interactive technologies.
4. **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.
5. **Interobserver Reliability** – reliability measured between two or more different examiners.
6. **Intraobserver Reliability** – reliability measured between one examiner with his or her self over serial reviews either with different modalities or by the same modality.
7. **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.
8. **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.
9. **Cost analysis** – an accounting of the cost, irrespective of effectiveness or benefit, of an intervention(s).
10. **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.
11. **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.

12. ***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 1.0, reported as simple proportion agreement. (1-7, 45, 46, 53, 59, 62, 72, 77, 79, 82, 86, 87, 95, 101, 105) (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	---
Ebner (72)	0.71-0.76	0.90-0.97
Tan (77)*	0.75-0.82	0.83-0.89
Silva (79)	0.86-0.91	0.96-1.0
Heffner (82)	0.69	---
Ribas (86)	0.78-0.84	0.92-0.98
Rubegni (87)	0.88	---
Lamel (95)	---	0.62
Kaliyadan (101)	---	0.95
Rubgeni (105)	0.88	---

Complete Agreement – considers the single most likely diagnosis.

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

**includes dermatoscopic images*

Another study found simple interobserver agreement among different teledermatologists to range from 0.77 to 0.91. (102)

Studies have employed examinations performed by different clinic-based examiners on the same patient sample to place interobserver reliability assessments in the context of a “baseline” level of agreement found among different in-person examiners. (5,86,95) In addition, 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 in the Whited et al. study. (Table 2) A second study performed with the same study design yielded similar conclusions with the major difference being that a higher level of complete agreement was noted (Table 3). (86) Another study reported simple diagnostic agreement between two clinic-based dermatologists to be 0.92 and 1.0 between two teledermatologist examiners. (95)

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>	0.54	(0.46 – 0.61)	0.92	(0.88 – 0.96)
<i>Clinic-based</i>	<i>Teledermatologist</i>	0.41 to 0.55	(0.34 – 0.63)	0.83 to 0.95	(0.78 – 0.98)
<i>Teledermatologist</i>	<i>Teledermatologist</i>	0.49 to 0.55	(0.41 – 0.63)	0.84 to 0.92	(0.79 – 0.96)

Complete Agreement – considers the single most likely diagnosis.

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

Table 3. Results of the Rabin 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>	0.83	(0.77 – 0.89)	0.94	(0.90 – 0.97)
<i>Clinic-based</i>	<i>Teledermatologist</i>	0.78 to 0.84	(0.71 – 0.89)	0.92 to 0.98	(0.87 – 0.1)
<i>Teledermatologist</i>	<i>Teledermatologist</i>	0.81	(0.74 – 0.87)	0.97	(0.93 – 0.99)

Complete Agreement – considers the single most likely diagnosis.

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

Another 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 vs. 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.

A final study found that among four in-person examiners, diagnostic agreement for the primary diagnosis was found in 10 of 15 cases (67%, 95% CI 33%-88%). (75) Individual examiner pairs agreed from 67% to 87% of the time.

Another study compared PASI and PPASI (Psoriasis Area and Severity Index and Palmoplantar Psoriasis Area and Severity Index) scores between face to face evaluators and teledermatologists. (78) High Spearman rank correlation coefficients were found between these two groups (0.71-0.98). Additionally, there was high correlation between the teledermatologists (correlation coefficient 0.93).

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) 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 various lesion categories. (5, 9, 56, 57, 64, 75, 77, 82, 95, 97, 101, 105). (Table 4)

Table 4. Diagnostic reliability measures using the kappa statistic.

Reference	Lesion Category	Agreement Category	Examiner Pairings	Kappa	95% CI ranges
Whited (5)	Malignancy	Complete	<i>Clinic-based vs. clinic-based</i>	0.68	0.52 – 0.83
Whited (5)	Malignancy	Complete	<i>Teledermatologist vs. teledermatologist</i>	0.68	0.59 – 0.77
Whited (5)	Malignancy	Partial	<i>Clinic-based vs. clinic-based</i>	0.77	0.62 – 0.92
Whited (5)	Malignancy	Partial	<i>Teledermatologist vs. teledermatologist</i>	0.63	0.55 – 0.72
Krupinski (9)	Various Lesion Types	Partial	<i>Clinic-based vs. teledermatologist</i>	0.80 to 0.82	---
Baba (56)	Various Lesion Types	Complete	<i>Teledermatologist vs. teledermatologist</i>	0.71	0.60 – 0.82
Moreno-Ramirez (57)	Various Lesion Types	Complete	<i>Teledermatologist vs. teledermatologist</i>	0.91	0.87 – 0.96
Moreno-Ramirez (57)	Various Lesion Types	Compete	<i>Clinic-based vs. teledermatologist</i>	0.90	0.90 – 1.0
Moreno-Ramirez (64)	Various Lesion Types (5 categories)	Complete	<i>Teledermatologist vs. teledermatologist</i>	0.85	0.79 – 0.91
Edison (75)	Various Lesion Types	Complete	<i>Clinic-based vs. clinic-based</i>	0.77	0.69 – 0.85
Tan (77)	Various Lesion Types	Partial	<i>Clinic-based vs. teledermatologist</i>	0.92-0.98	0.87-1.0
Tan (77)	Various Lesion Types	Partial	<i>Teledermatologist vs. Teledermatologist</i>	0.95	0.91-0.99
Heffner (82)	Various Lesion Types (Rash)	Complete	<i>Clinic-based versus teledermatologist</i>	0.65	0.58-0.73
Rubegni	Various	Complete	<i>Clinic-based</i>	0.86	(0.80-

(87)	Lesion Types		<i>versus teledermatologist</i>		0.93)
Lamel (95)	Various Lesion Types	Partial	<i>Clinic-based versus teledermatologist</i>	0.60	---
Senel (97)	Various Lesion Types	Complete	<i>Clinic-based versus teledermatologist</i>	0.75 - 0.77	(0.67-0.85)
Kaliyadan (101)	Various Lesion Types	Partial	<i>Clinic-based versus teledermatologist</i>	0.66	---
Rubegni (105)	Various Lesion Types	Complete	<i>Clinic-based versus teledermatologist</i>	0.86	(0.80 - 0.93)

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

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

For the Senel et al. study, kappa values were significantly increased to 0.85 -0.86 (95% CI 0.79 – 0.93) when dermatoscopic images were added to the teledermatology consult. (97)

Using teledermatoscopic images, kappa values of 0.56-0.78 were noted among teledermatologist examiners. (98) Images were obtained by general practitioners.

1b. Intraobserver Reliability. Table 5 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 rated by simple proportion agreement.

Table 5. 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
Ebner (72)	0.74	0.90
Tan (77)	0.74	0.88
Heffner (81)	0.82	---

Complete Agreement – considers the single most likely diagnosis.

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

A study making an intraobserver agreement assessment using the kappa statistic among 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 6 summarizes the point estimate data from these studies.

Table 6. 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 7)

Table 7. 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>	0.94	(0.87 – 1.0)	1.0	---
<i>Clinic-based</i>	<i>Teledermatologist</i>	0.78	(0.68 – 0.88)	0.99	(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 studies that have reported intraobserver agreement among clinic-based examiners and teledermatologists are shown in Table 8.

Table 8. Intraobserver diagnostic reliability between for a clinic-based examination and teledermatology review – 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)

In another study intraobserver agreement between an in-person evaluation and teledermatology was found to be 0.90 (simple agreement) with a kappa value of 0.84. (106) The assessment made was benign versus malignant.

3. Diagnostic Reliability – Combined (Hybrid) 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).

Another study compared in-person examinations, store and forward, and live-interactive examinations on a single patient population. (75) An identical diagnosis

was obtained among all three modalities in 70 of 110 patients (64%, 95% CI 55%-73%). In-person examiners and live-interactive examiners agreed in 88 of 110 cases (80%, 95% CI 73%-88%); in-person examiners agreed with store and forward examiners in 80/110 cases (73%, 95% CI 64%-81%); and live-interactive examiners agreed with store and forward examiners in 77 of 110 cases (70%, 95% CI 61%-79%). Corresponding kappa values were 0.79 (95% CI 0.75-0.83); 0.71 (95% CI 0.67-0.76; 0.68 (95% CI 0.64-0.73) respectively.

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 reliability found in 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 existing studies that have found comparable reliability.

Part 2. Management Reliability and Accuracy

1. Management Reliability – Store and Forward.

1a. Interobserver Reliability. The studies that have assessed reliability of biopsy or operative recommendations between a teledermatologist and an in-person dermatologist are presented in Table 9.

Table 9. 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
Rubegni (87)**	0.86	0.70	(0.49-0.91)
Barbieri (99)	---	0.35 – 0.61	(0.12 – 0.82)

* includes recommendations to “biopsy” or “excise”

** agreement on surgical technique

Studies that have assessed other categories or definitions of management are presented in Table 10.

Table 10. Interobserver agreement between teledermatologists and clinic-based evaluations for various management categories.

	Management Definition or Categories	Simple Agreement (95% CI)	Kappa (95% CI)
Lamel (95)	“Designated treatment recommendations	0.81 (0.72-0.88)	0.57
Senel (97)	Destruction, medical treatment, or follow-up	---	0.67 -0.70 (0.55-0.82) 0.73-0.76 (0.62-0.87)*
Kaliyada (101)	Multiple treatment categories	---	0.82
Rubegni (105)	“Local, systemic, or surgical”	0.70	0.64 (0.54 – 0.75)
Barbieri (99)	Triage decisions –	---	0.41 -0.48 (95%

	“same day, next day, while inpatient, as outpatient”		CI 0.18 - .65)
Oakley (59)	“Excise/curette/biopsy, cryotherapy, leave alone, other”	0.82	---
Romero (80)	Diagnostic tests	0.96	---
	Need for follow-up	0.96	---
	Treatment recommendations	0.85	---
Whited (5)	Medical therapy	0.68-0.79 (0.61-0.85)	---
	Clinic-based therapy	0.56-0.68 (0.49-0.75)	---
	Diagnostic testing	0.63-0.67 (0.56-0.74)	---

* dermatoscopic images

For the Senel et al. study that found management plan reliability (“destruction, medical treatment, or follow-up”) to have a kappa value of 0.67 – 0.70 (95% CI 0.55 – 0.82) between teledermatologists and in-person examiners, the kappa values were non-significantly increased to 0.73 – 0.76 (95% CI 0.62 – 0.87) when dermatoscopic images were added to the teledermatology consult. (97)

In the Barbieri et al. study that assessed triage decision reliability between in-person dermatologists and teledermatologists in an inpatient population an in-person dermatologist determined that 66% of patients could be triaged to the next day or later compared to 60% for two teledermatologists. (99)

In the Whited et al. study management reliability was assessed 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.

In other studies that assessed management reliability:

Among 58 subjects, the in-person dermatologists and two different teledermatologists agreed completely on the number of patients that needed admission to the hospital (six) and referral for a surgical intervention (four). (72)

A randomized clinical trial found that management recommendations differed between teledermatologist vs. 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.

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.

2a. Intraobserver Reliability.

In the Barbieri et al. study that assessed triage decisions, triage reliability between the two teledermatologists was 0.41 (95% CI 0.42 – 0.84). (99)

Using teledermatoscopic images, kappa values of 0.31-0.38 were noted among teledermatologist examiners for management plans (“no treatment, excision, cryotherapy, or topical medication.”) (98) Images were obtained by general practitioners.

A study found management concordance (multiple medical management categories) to yield a kappa value of 0.82. (101)

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)

2. Management Reliability – Real Time Interactive.

1a. Interobserver Reliability. One study that assessed the reliability of biopsy recommendations between a teledermatologist and an in-person dermatologist is presented in Table 11.

Table 11. 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

In other studies that assessed management reliability:

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.

3. Management Reliability – Combined (Hybrid) Modalities.

1a. Interobserver Reliability. One study compared in-person examinations, store and forward, and live-interactive reviews on a single patient population. (75) For management plans, in-person examiners agreed with store and forward examiners in 73 of 110 cases (66%, 95% CI 58%-75%); in-person examiners agreed with live-interactive examiners in 82 of 110 cases (75%, 95% CI 66%-83%); live-interactive examiners agreed with store and forward examiners in 70 of 110 cases (64%, 95% CI 55%-73%). Corresponding kappa values were 0.62 (95% CI 0.56-0.69); 0.71 (95% CI 0.64-0.78); 0.59 (95% CI 0.52-0.65), respectively.

1b. Intraobserver Reliability. Another study reported intraobserver agreement between face to face and live-interactive teledermatology to be 0.92 for diagnostic test agreement, 0.91 for need of follow-up, and 0.79 for treatment recommendations. (80)

4. Management Accuracy – Store and Forward.

One study utilized consensus opinion of an expert panel as a reference standard to assess management decisions, comparing teledermatologists to in-person dermatologists for non-pigmented neoplasms. (71) Management plans for teledermatologists and in-person dermatologists were compared to the consensus opinion management plans provided by the expert panel. The study was designed to test equivalence between the two modalities. Management plan accuracy for teledermatologists was rated at 78.8% compared to 83.4% for in-person dermatologists. Since the difference in accuracy rates was less than 10% [-4.68% (-7.13 to -2.23%)] the two modalities were considered equivalent.

Another study (81) that utilized consensus opinion of an expert panel as a reference standard to assess management decisions compared in-person dermatologists to teledermatologists for pigmented neoplasms. The study evaluated face to face diagnosis with store and forward macro images as well as images obtained with polarized light dermatoscopy (PLD) and contact immersion dermatoscopy (CID). Management plans were superior for teledermatology for all categories when all lesion types were analyzed. When lesion types were dichotomized into benign and malignant lesions teledermatology was superior to in-person management for benign lesions but was inferior to in-person care for malignant lesions. Seven index melanomas were mis-managed with teledermatology compared to one for in-person care, although no statistical significance could be attached to this finding for melanoma.

Summary: High simple agreement has been found for biopsy and other management decisions made by teledermatologists and clinic-based dermatologists when using both store and forward and real time interactive techniques. Kappa statistics have generally shown high strength of agreement. In two studies designed to test for non-inferiority, or equivalence, Warshaw, et. al. demonstrated comparable management decisions made by teledermatologists compared to in-person dermatologists for non-pigmented lesions. (71) For pigmented lesions, management plans were superior for teledermatology versus in-person care in the aggregate, but teledermatology was inferior to in-person care for the subset of malignant neoplasms. (81). 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: Because of the aforementioned limitations of management research, correlating reliability or accuracy data with processes of care, clinical outcomes, and economic outcomes would be 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 12. 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, 91) whereas another study found higher accuracy rates among teledermatologists. (66) Two studies found significantly worse diagnostic accuracy rates among teledermatologists compared to in-person examinations. (71, 81) Less conclusive studies correlated histopathologic review with traditional photographs and referral letters (17) and analyzed a very small sample size (18).

Table 12. Diagnostic accuracy rates by consult modality.

Reference	Modality	Complete Accuracy Rate	95% CI ranges	Partial Accuracy Rate	95% CI ranges
Whited (5)	<i>Clinic-based</i>	0.59 - 0.71	0.48 – 0.81	0.85	0.77 – 0.93
	<i>Teledermatology</i>	0.53 - 0.63	0.42 – 0.74	0.68 – 0.85	0.58 – 0.93
Krupinski (9)	<i>Clinic-based</i>	---	---	0.80 – 0.97	---
	<i>Teledermatology</i>	---	---	0.73 – 0.78	---
Harrison (17)	<i>Clinic-based</i>	---	---	---	---
	<i>Teledermatology</i>	0.71	---	---	---
Whited (18)	<i>Clinic-based</i>	0.70 - 0.77	---	0.80 – 0.92	---
	<i>Teledermatology</i>	0.31 - 0.85	---	0.85	---
Moreno-Ramirez (57)	<i>Teledermatology</i>	0.79	---	---	---
Oakley (59)	<i>Clinic-based</i>	0.72	0.53-0.87	---	---
	<i>Teledermatology</i>	0.71	0.56-0.83	---	---
Lozzi (66)	<i>Clinic based</i>	0.30-0.42	0.15-0.53	---	---
	<i>Teledermatology</i>	0.79	0.72-0.93	---	---
Warshaw (71)	<i>Clinic based</i>	0.56	0.53-0.60	0.76	0.73-0.79
	<i>Teledermatology</i>	0.43	0.39-0.47	0.59	0.56-0.63
Warshaw (81)	<i>Clinic-based</i>	---	---	0.80	---
	<i>Teledermatology</i>	---	---	0.64	---
Rios-Yuil (91)	<i>Teledermatology</i>	0.67	0.50-0.84	---	---
	<i>Face to face*</i>	0.57	0.39-0.74	---	---
Senel (97)	<i>Teledermatology</i>	0.85-0.88	---	---	---

* Diagnoses made during a case conference

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 of 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.

Yet another study used macro and dermatoscopic images to generate sensitivity and specificity values for teledermatology based on pathology results. (77) For melanoma the study found a sensitivity of 100% and a specificity that ranged from 98.4 to 99.5%. For squamous cell carcinoma the sensitivity was 100% and the specificity ranged from 96.3-97.1%. Of note, this study identified eight skin lesions incorrectly identified as a skin cancer by in-person examiners that were subsequently shown to be a benign condition. These eight lesions were correctly identified as benign lesions by the teledermatologists. This finding points out why using face to face diagnoses is methodologically flawed when a gold standard test exists to categorize the skin condition.

The study by Warshaw (71) was an equivalency trial comparing diagnostic accuracy between teledermatology and in-person evaluations using histopathological diagnoses as the reference standard for non-pigmented skin lesions. Equivalence was defined as a difference in accuracy of less than or equal to 10% between modalities. For both the primary diagnoses and aggregate (differential) diagnoses, teledermatology performed worse than conventional care. For aggregated diagnoses the difference between modalities was -16.6% (-20.2% to -13.0%) with teledermatologists' accuracy of 59.5% compared with an in-person rate of 76.1%. For the primary diagnose the difference was -13.3% (-17.4% to -9.29%) with a teledermatologists' accuracy rate of 42.9% compared with an in-person rate of 56.3%.

In another study by Warshaw (81) an equivalency trial was designed to compare diagnostic accuracy for pigmented skin lesions, again using histopathological diagnoses as the reference standard. Equivalence was again defined as a difference in accuracy of less than or equal to 10% between modalities. The study evaluated face to face diagnosis with store and forward macro images as well as images obtained with polarized light dermatoscopy (PLD) and contact immersion dermatoscopy (CID). Accuracy rates considered the single most likely diagnosis and differential diagnoses. Teledermatology performed significantly worse (non-

equivalence) than in-person diagnoses for all lesion types in all categories with the exception of the single most likely diagnosis when using CID teledermatology. For the subcategory of malignant lesions, teledermatology was likewise inferior to in-person diagnosis for aggregated (differential) diagnosis

For the Senel et al. (97) study the accuracy rate was increased from 0.85-0.88 to 0.94-0.95 with the addition of dermatoscopic images to the teledermatology consult.

A study by Kroemer et al. (106) reported sensitivity and specificity of four diagnostic categories compared to histopathology or a face-to-face diagnosis. For benign nonmelanocytic, benign melanocytic, malignant nonmelanocytic, and malignant melanocytic categories the sensitivity of teledermatology was 0.76, 0.87, 0.97, 1.0, respectively. The corresponding specificity values were 0.97, 0.99, 0.92, and 0.98.

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. Most of the 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 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. However, the most recently published study found contradictory evidence. (71) Analyzing accuracy rates for non-pigmented skin lesions and comparing diagnoses to histopathologic review of biopsies tissue, teledermatology performed worse than conventional in-person dermatologist diagnosis.

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. Finally, studies that evaluate subsets of skin conditions, such as the assessment of non-pigmented skin lesions by Warshaw et al. (71, 81)

should be pursued. While teledermatology appears to function well compared to conventional care across the spectrum of skin disease, it is possible that there are certain skin conditions that may not be as amenable to teledermatologic care if studied as distinct entities.

Part 4. Clinical Outcomes

1. Clinical Outcomes – Store and Forward

Two randomized trials have made clinical course assessments between patients undergoing a teledermatology consultation and those undergoing a conventional clinic-based consult process. (61, 88) In one study a dermatologist blinded to the randomization assignment rated the clinical course of the referred skin conditions between baseline and 4 months. (61) Skin conditions were rated as “improved,” “no change,” and “worse.” Table 13 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 14 shows the results of the second study. (88) A three-dermatologist panel, blinded to the randomization assignment, rated the clinical course as “resolved,” “improved,” “unchanged, not clinically relevant,” “unchanged, clinically relevant,” and “worse.” Assessments were made between baseline and the first clinic visit (if one occurred) and between baseline and 9 months. No significant differences were found in the ratings.

Table 13. Clinical course ratings from baseline to four months by examination modality (61).

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

Table 14. Clinical course ratings from baseline to first clinic visit and baseline to 9 months. (88)

Randomization Group	Clinical Course Rating					p value
	Resolved	Improved	Unchanged - not clinically relevant	Unchanged - clinically relevant	Worse	
Baseline to First Clinic Visit						
Conventional Care n = 137	2.2% (3)	21.2% (29)	14.6% (20)	51.1% (70)	10.9% (15)	0.645
Teledermatology n = 94	2.1% (2)	23.2% (22)	11.6% (10)	56.8% (54)	6.3% (6)	
Baseline to Nine Months						
Conventional Care n = 136	25.7% (35)	46.3% (63)	11.0% (15)	12.5% (17)	4.4% (6)	0.880
Teledermatology n = 125	24.6% (31)	46.8% (59)	10.3% (13)	10.3% (13)	7.9% (9)	

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.”

The studies in Table 15 evaluated the proportion of store and forward teledermatology consults that did avoid (or would have avoided) a clinic visit to a dermatologist. 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) The study by van der Heijden JP (84) evaluated dermatologist to dermatologist telemedicine referrals.

Table 15. 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%
Eminovic (70)	39% (78/200)
Ebner (72)	53-59% (31/58-34/58)
van der Heijden (84)	71% (12/17)
van der Heijden (92)	74% (19,741/26,596)
van der Heijden (96)	81% (43/53)

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).

Yet another study found that the median waiting times for a clinic visit for patients with suspected skin cancers were lower for telemedicine compared to conventional referral processes. (69) Median waiting times for telemedicine patients with melanoma was 14 days (range 1-34) compared to 24 days (range 6-59) for patients with melanoma managed by conventional referral. Data for patients with SCC was 13.5 days (range 11-19) and 24 days (range 1-42), respectively. Time to treatment

was also quicker with telemedicine. Patients with melanoma were treated in a median of 21.5 days (range 7-47) via telemedicine compared to a median of 41 days (range 14-119) for conventional care. For SCC times to treatment were a median of 56 days (range 37-167) and 73 days (range 1-248), respectively.

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) Another 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. Yet 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.

A retrospective chart review evaluated patients seen at a Dermatology Surgery Clinic and compared how patients flowed through the Dermatology consult system based on whether they were teledermatology referrals or conventionally-referred patients. (74) Compared to conventionally-referred patients, teledermatology patients reached a point of initial evaluation sooner (4 days versus 48 days, $p < 0.0001$) and received a biopsy sooner (38 days versus 57 days, $p = 0.034$). Likewise, a significant improvement in time until seen in the Dermatology Surgery Clinic was found for teledermatology compared to conventional care (104 days versus 125 days, $p = 0.006$). There was not a significant difference between groups for the time period from biopsy to surgical clinic intervention ($p = 0.678$).

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)

A retrospective chart review study found that time to biopsy for patients with skin cancer was 13.8 days for conventional care referrals and 9.7 days for teledermatology patients ($p < 0.0001$). (103)

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.

Another study performed a retrospective chart review of teledermatology patients that had two or more teledermatology encounters. (94) Clinical improvement was recorded for 69% of the teledermatology patients.

Studies that have evaluated the proportion of real-time interactive teledermatology consults that avoided a clinic-based visit to a dermatologist. (Table 16)

Table 16. 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)

Another study found that only 4.3% of patients presented to a university-based dermatology clinic after a state-wide real-time teledermatology intervention, although an assessment of clinic-based care outside the university setting was not assessed. (89) In 79% of these clinic-based encounters the reason for the visit was for a procedure or other clinic-based intervention.

Studies have 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 17.

Table 17. Time study and travel distance data for real-time interactive teledermatology consultations.

Reference	Total Time (minutes)*		Distance traveled (km)		Dermatologist consult time (minutes)	
	Real-time	Clinic-based	Real-time	Clinic-based	Real-time	Clinic-based
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 two large studies have been published that assess 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 half of teledermatology consults do not require a clinic-based visit. 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 similar proportion of real-time interactive consultations avoid the need for a clinic-based evaluation, however, time requirements to perform these consultations are comparable 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 a vital area to target for future teledermatology research. Future studies that confirm or refute the findings of the Pak et al. and Whited et al. studies (61, 88) that suggest equivalent clinical outcomes are achieved when store and forward teledermatology would be useful. Similarly, an assessment of the clinical outcomes of patients undergoing real-time interactive consults should be performed.

Part 5. Quality of Life

1. Quality of Life - Store and Forward

One study made a quality of life assessment among users of a teledermatology intervention. (38) Although there was no conventional care group for comparison, the Dermatology Quality of Life scores for the teledermatology patients were considered comparable to in-person dermatology outpatients.

Another study randomized referrals to a Dermatology consult service to store and forward teledermatology or a conventional referral process. (100) Quality of life was measured using the Skindex-16© at 3 and 9 months post-referral. At 3 months patients in both randomization groups experienced an improved quality of life score, with teledermatology patients showing a clinically significant improvement in the “emotions” domain. At 9 months post-referral both randomization groups experienced an improved quality of life score, with teledermatology and conventional care patients showing a clinically significant improvement in the “symptoms” and “emotions” domains and the composite score. No statistically significant differences between randomization groups were found for any domain or composite score.

2. Quality of Life – Real-time Interactive

No studies have been published on real-time interactive teledermatology and quality of life.

Summary: Quality of life investigation is a nascent area in the teledermatology literature. Only two studies have assessed quality of life when using store and forward teledermatology. A randomized trial showed an improved quality of life over time with no evidence to suggest a difference between quality of life improvements seen with store and forward teledermatology compared to conventional referrals.

Directions for Future Research: Quality of life is an important metric in dermatology and additional studies that assess teledermatology’s impact on quality of life would be a necessary addition to the teledermatology knowledge base.

Part 6. 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 are incurred by patients or employers for loss of work, productivity, or travel. Thus, both economic perspectives are important.

1. Economic Analyses – Store and Forward

A study by Whited et al. found that, from the United States Department of Veterans Affairs economic 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 United States Department of Veterans Affairs, costing only an additional 0.17¢ per patient per day of time to intervention saved.

A cost minimization analysis conducted in the Netherlands found that store and forward teledermatology was more costly than conventional care (€387 versus €354, respectively). (85) The economic perspective was societal. A sensitivity analysis found that costs could be equivalent if a higher proportion of referrals were avoided or if the distances traveled for dermatologic care were higher than noted, although these break-even points were at the very highest range of expected values.

A cost-effectiveness analysis performed among patients being referred for suspect skin cancers found that teledermatology was the dominant strategy – meaning that it was both less costly and more effective. (73) The effectiveness measure was time to intervention (in days). Teledermatology cost was €79.78 per patient compared to €129.37 per conventional care patient. Teledermatology patients were seen in 12.3 days compared to 88.6 days for conventionally referred patients. The economic perspective taken was a societal perspective.

A study by Pak et al. took the economic perspective of the Department of Defense (76). Since a clinical course analysis found comparable clinical outcomes between patients managed by store and forward teledermatology and conventional in-person care, this study was a cost minimization analysis. Direct costs indicated a slight cost advantage for conventional care (average cost of \$283 per patient for

conventional care versus \$294 for teledermatology). However, when lost productivity costs were considered, teledermatology resulted in a lower cost (\$340 per patient for teledermatology versus \$372 per patient for conventional care).

A study by van der Heijden found that teledermatology was the less costly alternative. (92) From the health care sector perspective, the average cost per patient for teledermatology was €157.06 compared to €192 for conventional care.

A study by Zelickson 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 studies have assessed the economic impact of real-time interactive teledermatology consult systems and are summarized in Table 18.

Table 18. 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 (per patient)	£48.73 (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 (per patient)	£48.77 (per patient)	Societal	Rural Community Care
Lamminen (26)	Cost	FM18,627 (total cost)	FM18,034 (total cost)	Societal	Community Care
Bergmo (33)	Cost-minimization	NKr470,780 (total cost)	NKr635,075 (total cost)	Health care sector	Community Care
Loane (31)	Cost-minimization	NZ\$279.23 (per patient)	NZ\$283.70 (per patient)	Societal	Rural Community Care
Chan (34)	Cost	HK\$57.7	HK\$322.8	Health care sector	Institutionalized patients
Persaud (54)	Cost-minimization	C\$619.02 - 4,163.09 (per patient)	---*	Societal	Community Care

Armstrong (63)	Cost-minimization	\$274 hourly operating cost	\$346 hourly operating cost	Health care sector	Community Care
Dekio (90)	Cost	¥26,040	¥60,500	Societal	Rural 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 has shown that teledermatology is (or can be) cost saving from a societal perspective and can be either a dominant strategy or cost-effective strategy. 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. It appears that when teledermatology is found to be cost saving, it largely is due to cost avoidance by averting travel and decreasing loss of productivity or decreasing loss of time from employment. Studies that include the societal perspective are recommended.

Part 7. 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 19. 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) The study by Hsueh et al. found no statistical difference in satisfaction between teledermatology patients and conventional care patients. (93)

Table 19. Major findings from store and forward patient satisfaction assessments.

Reference	Positive Features and Comments	Negative Features and Comments	Overall Satisfaction
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%
Hsueh (93)	66% preferred teledermatology to face to face care	Dissatisfied patients did not believe they received proper treatment and adequate follow-up care	77% (4.1 on a five point scale)
Kaliyadan (101)	94% thought teledermatology eliminated the need for in-person evaluation	14% refused photography	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 20. In studies by Collins et al. and Bowns et al. referring clinicians did not have favorable opinions of teledermatology. (43, 62) Of note, the referring clinicians in these studies were required to generate and send the teledermatology consults.

Table 20. Major findings from store and forward referring clinician satisfaction assessments.

Reference	Positive Features and Comments	Negative Features and Comments	Overall Satisfaction
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%
Ou (83)	83% found the teledermatology system easy to use; 89% were likely to use the system again	41% believed it was unlikely that teledermatology would help reduce consultation time	---

McFarland (104)	86% thought it was a good addition to regular services; 95% found the continuing education program useful	Problems with computers or information technology; 24% preferred process of teledermatology over a face-to-face visit	71%
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**Referring clinicians were nurses*

1c. Consultant Satisfaction.

Those studies that have made assessments of dermatologist consultants' satisfaction appear in Table 21.

Table 21. Major findings from store and forward consultant satisfaction assessments.

Reference	Positive Features and Comments	Negative Features and Comments	Overall Satisfaction
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

1a. Patient Satisfaction.

The major findings from the literature on patient satisfaction with real-time interactive technology appear in Table 22. As with store and forward consults, patients expressed no strong preference for usual care versus teledermatology. (11, 16, 40)

Table 22. Major findings from real-time interactive patient satisfaction assessments.

Reference	Positive Features and Comments	Negative Features and Comments	Overall Satisfaction
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%

1b. Referring Clinician Satisfaction.

Referring clinician satisfaction assessments when using real-time interactive technology appear in Table 23.

Table 23. Major findings from real-time interactive referring clinician satisfaction assessments.

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

1c. Consultant Satisfaction.

Satisfaction among dermatologist consultants using real-time interactive technology appears in Table 24.

Table 24. 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, has been a problem identified with store and forward consults. Patients have expressed ambivalence about a preference for teledermatology vs. usual care, suggesting that they perceive either of these options to be an 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 a 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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