

Teledermatology



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KEYWORDS

- Telemedicine • Teledermatology • Digital imaging • Diagnosis • Clinical outcomes
- User satisfaction

KEY POINTS

- Teledermatology can be performed using store and forward technology, real-time interactive technology, or a hybrid technique that combines both elements.
- Teledermatology has been found to be a diagnostically reliable means of diagnosing skin conditions. The evidence for diagnostic accuracy has been more equivocal.
- In-person dermatology visits decrease by an average of 45.5% to 61.5% for store and forward teledermatology and real-time interactive teledermatology, respectively.
- Clinical outcomes for patients being referred to or managed by teledermatology have been comparable with conventional care.
- Overall, patients are satisfied with teledermatology. Accessibility and averted travel are cited as positive features.

INTRODUCTION

Telemedicine has transitioned, albeit not completely, from an alternative method of health care delivery to simply a means of delivering health care. Teledermatology, one of the more common applications of telemedicine, is also one of the more mature disciplines in telemedicine. Primary care clinicians who are not current users

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of teledermatology will likely be exposed to teledermatology, or at least the opportunity to use teledermatology, in the future. Although increasingly ubiquitous, teledermatology does alter how care is delivered and affects the experience of the referring clinician, the patient, and the dermatologist. This article emphasizes how those features affect the referring clinician who, most often, is a primary care clinician. The evidence of most relevance to a primary care clinician, namely, diagnostic reliability, diagnostic accuracy, clinical outcomes, and user satisfaction, is the focus of this review.

TELEDERMATOLOGY MODALITIES

Teledermatology is performed by using either a store and forward technique or real-time interactive technology. A third method, a hybrid of these 2 methods, integrates aspects of both modalities. The key features of each modality are described in **Table 1**.

STORE AND FORWARD

The store and forward technique has emerged as the most commonly used modality in teledermatology. In general, it consists of high-resolution digital images bundled with standardized historical and clinical information. Questions such as the duration of presence of the referred condition, a change in size, or if the lesion is pruritic are typical components of a standardized history. Customarily, an imaging convention or protocol is followed to obtain the image set.¹ The consult requests are sent electronically from the site of the referring clinician and patient to the site of the consulting dermatologist, often via an electronic health record or any other electronic means that meets all applicable security and privacy requirements. The distinguishing feature of store and forward teledermatology is a separation of the referring clinician and patient from the dermatologist in both time and place. For example, a consult request placed on day 1 by a referring clinician from one geographic site is reviewed on day 2 by a

Table 1
Key features of teledermatology modalities

Modality	Key Features
Store and forward	<ul style="list-style-type: none"> • Uses still digital images • Includes historical information, often standardized • Patient and dermatologist are separated in space and time; asynchronous • No or minimal interaction between patient and dermatologist • Logistically straightforward
Real-time interactive	<ul style="list-style-type: none"> • Uses videoconferencing technology • Allows for verbal interaction between patient, referring clinician (if present), and dermatologist • Patient and dermatologist are separated by space but not time; synchronous • Logistically more complex
Hybrid	<ul style="list-style-type: none"> • Uses videoconferencing technology with higher-resolution still digital images as an adjunct • Allows for patient interaction • Patient and dermatologist are separated by space but not time; synchronous

dermatologist located at another geographic site. For the majority of store and forward consultations, there is no direct interaction between the dermatologist and the patient within the confines of the teledermatology consultation. The dermatologist's conclusions and recommendations are sent back to the referring clinician who conveys this information to the patient and implements the recommendations, if any.

Real-Time Interactive

The real-time interactive technique uses videoconferencing technology to perform the teledermatology consultation. The patient, dermatologist, and usually an individual at the referring site, facilitator, technician, or referring clinician, are present and interact via the videoconference. A functional difference of this modality compared with store and forward is that, although there is a separation of patient and dermatologist by space, there is not a separation in time. Therefore, a logistical consideration when using real-time interactive technology is scheduling both sites to be available at the same time. Consults performed across different time zones can add to the scheduling complexity. This technique does allow the dermatologist and patient to verbally interact in much the same manner as would occur in an in-person clinic visit.

Hybrid

As the name implies, hybrid modalities integrate features of both store and forward and real-time interactive technologies. High-resolution digital images are often reviewed in the context of the interactive features that videoconferencing allows. During the consult session, the dermatologist can direct the number and location of still digital images he or she feels is necessary to complete the evaluation. The higher-resolution still images augment the lower-resolution images that are typical of videoconferencing technology. Thus, this modality allows for the dermatologist to interact with the patient in real time and to review high-resolution still digital images of the affected skin before, during, and after the interaction.

DIAGNOSTIC RELIABILITY AND ACCURACY

A question relevant for referring clinicians to ask is how does teledermatology diagnosis compare with diagnosis that would be made if patients were evaluated via an in-person face to face evaluation? Likewise, this same question should be asked by patients and dermatologists. There are 2 salient features of the diagnostic process, interobserver diagnostic reliability and diagnostic accuracy.² Reliability refers to agreement or the repeatability or reproducibility of a diagnostic assessment. If 2 examiners independently evaluate the same skin lesion and both conclude that it is a basal cell carcinoma, then the diagnoses they provided are reliable. However, if one examiner believes the skin lesion to be a basal cell carcinoma and the other diagnoses it as sebaceous hyperplasia, then their diagnoses differ and are considered to be unreliable.

Accuracy reflects whether the diagnoses reached are correct or incorrect and is assessed by comparing the diagnosis with a reference standard test, also termed a gold standard test. If after a biopsy and histopathologic review of tissue (reference standard test) the above-mentioned lesion is determined to be a basal cell carcinoma, then in the first scenario both examiners provided an accurate diagnosis of basal cell carcinoma. In the second scenario, one examiner was accurate (basal cell carcinoma) and one was inaccurate (sebaceous hyperplasia). As a final alternative, if the biopsy reveals that the lesion is a squamous cell carcinoma, then, in both cases, the examiners provided inaccurate diagnoses.

Reliability of Teledermatology Modalities

Store and forward

Several studies have reported interobserver agreement between teledermatologists and dermatologists providing in-person evaluations. Simple percentage agreement has ranged from 41% to 100%.^{3–25} As might be expected, greater agreement is noted when overlap between differential diagnoses is counted as agreement compared with agreement based only on a single most likely diagnosis (**Table 2**).

Two studies provided a context for teledermatologist versus in-person dermatologist agreement by assessing the level of agreement found among different in-person dermatologists. One of these studies found that 2 in-person dermatologists agreed on a diagnosis 54% of the time (95% confidence interval [CI], 46%–61%) for the single most likely diagnosis and 92% of the time (95% CI, 88%–96%) when agreement based on differential diagnoses was considered.⁷ With the same patient sample, the range for agreement between teledermatologists and clinic-based dermatologists was 41% to 55% (95% CI, 34%–63%) for the single most likely diagnosis and 79% to 95% (95% CI, 72%–98%) when differential diagnoses were included. The overlapping confidence intervals provide no evidence to suggest a difference in reliability for the

Table 2

Interobserver reliability between teledermatologist and in-person dermatologist evaluations reported as simple percentage agreement: store and forward teledermatology

Reliability Assessment by Diagnostic Category		
Single Most Likely Diagnosis (%)	Differential Diagnoses Included (%)	Reference
61–64	67–70	Kvedar et al, ³ 1997
88	—	Zelickson & Homan, ⁴ 1997
90	—	Lyon & Harrison, ⁵ 1997
64–77	81–89	High et al, ⁶ 2000
41–55	79–95	Whited et al, ⁷ 1999
44–51	57–61	Taylor et al, ⁸ 2001
73–85	83–89	Lim et al, ⁹ 2001
41	51	Eminovic et al, ¹⁰ 2003
54	63	Du Moulin et al, ¹¹ 2003
44–48	64–65	Mahendran et al, ¹² 2005
53	64	Oakley et al, ¹³ 2006
56	68	Tucker & Lewis, ¹⁴ 2005
55	—	Bowns et al, ¹⁵ 2006
71–76	90–97	Ebner et al, ¹⁶ 2008
87–92	96–100	Silva et al, ¹⁷ 2009
69	—	Heffner et al, ¹⁸ 2009
78–84	92–98	Ribas et al, ¹⁹ 2010
88	—	Rubegni et al, ²⁰ 2011
—	62	Lamel et al, ²¹ 2012
—	95	Kaliyadan et al, ²² 2013
72–73	88–92	Aguilera et al, ²³ 2014
91	—	Nami et al, ²⁴ 2015
46–76	79–91	Warshaw et al, ²⁵ 2015

teledermatologist versus in-person dermatologist pairs when compared with diagnostic agreement found among different in-person dermatologists. Another study of similar design yielded similar results. Agreement between teledermatologists and in-person dermatologists was 78% to 84% (95% CI, 71%–89%) for the single most likely diagnosis and 92% to 98% (95% CI, 87%–100%) when differential diagnoses were included¹⁹ this compared with 83% (95% CI, 77%–89%) agreement for in-person dermatologists for the single most likely diagnosis and 94% (95% CI, 90%–97%) agreement for differential diagnoses.

Real-time interactive

A smaller body of evidence has shown that interobserver diagnostic reliability values for real-time interactive consultations are fairly similar to store and forward interventions.^{26–32} Between teledermatologists and in-person dermatologists, agreement on a single most likely diagnosis has ranged from 54% to 80% and agreement that includes differential diagnoses has ranged from 76% to 99% (**Table 3**). One study made simultaneous assessments of agreement among different in-person dermatologists compared with a teledermatologist versus in-person dermatologist pairing.²⁶ For the in-person dermatologists, agreement on the single most likely diagnosis was 94% (95% CI, 87%–100%) and 100% when differential diagnoses were included. For the teledermatologist versus in-person dermatologist pairing, agreement on the single most likely diagnosis was 78% (95% CI, 68%–88%) and 99% (95% CI, 97%–100%) for differential diagnoses. Thus, no evidence to suggest a difference in reliability was found.

Accuracy of Teledermatology Modalities

The assessment of accuracy in dermatology is difficult.³³ Accuracy evaluation requires the ability to apply a reference standard test. Histopathologic review of biopsied tissue can serve as a reference standard test, although its primary uses are to distinguish benign from malignant tumors and to support a clinicopathologic correlation. Because histopathologic assessment is often not definitively specific, applying this as a gold standard to the clinical diagnosis can be problematic.

Store and forward

With these limitations in mind, several studies have compared the accuracy of store and forward teledermatology with in-person dermatology with the use of reference standard tests.^{7,13,34–41} The conclusions have varied, ranging from diagnostic superiority for teledermatology³⁶ and comparable accuracy rates^{7,13,35,39–41} to inferiority of teledermatology (**Table 4**).^{34,37,38}

Table 3
Interobserver reliability between teledermatologist and in-person dermatologist evaluations reported as simple percentage agreement: real-time interactive teledermatology

Reliability Assessment by Diagnostic Category		
Single Most Likely Diagnosis (%)	Differential Diagnoses Included (%)	Reference
78	99	Lesher et al, ²⁶ 1998
54	80	Gilmour et al, ²⁷ 1998
80	—	Lowitt et al, ²⁸ 1998
60	76	Loane et al, ²⁹ 1998
77	—	Phillips et al, ³⁰ 1997
59	—	Phillips et al, ³¹ 1998
72	86	Nordal et al, ³² 2001

Table 4
Diagnostic accuracy rate comparing in-person evaluation: store and forward technology

Modality	Accuracy Assessment by Diagnostic Category		
	Single Most Likely Diagnosis (%) (95% CI)	Differential Diagnoses Included (%) (95% CI)	Reference
In person	59–71 (48–81)	85 (77–93)	Whited et al, ⁷ 1999
Teledermatology	53–63 (42–74)	68–85 (58–93)	
In person	72 (53–87)	—	Oakley et al, ¹³ 2006
Teledermatology	71 (56–83)	—	
In person	—	80–97	Krupinski et al, ³⁴ 1999
Teledermatology	—	73–78	
In person	70–77	80–92	Whited et al, ³⁵ 1998
Teledermatology	31–85	85	
In person	30–42 (15–53)	—	Lozzi et al, ³⁶ 2007
Teledermatology	79 (72–93)	—	
In person	56 (53–60)	76 (73–79)	Warshaw et al, ³⁷ 2009
Teledermatology	43 (39–47)	59 (56–63)	
In person	59	80	Warshaw et al, ³⁸ 2009
Teledermatology	50	64	
In person	57 (39–74)	—	Rios-Yuil, ³⁹ 2012
Teledermatology	67 (50–84)	—	
In person	84 (70–98)	—	Barnard & Goldyne, ⁴⁰ 2000
Teledermatology	73 (56–90)	—	
In person	43 (35–51)	—	Jolliffe et al, ⁴¹ 2001
Teledermatology	47 (39–55)	—	

Real-time interactive

Only 1 study has evaluated the accuracy of real-time interactive technology.²⁸ Although the study primarily assessed diagnostic reliability, an accuracy assessment was performed from the 11 histopathologic findings that were available. For the in-person evaluation, 7 of 11 (64%) diagnoses were accurate and 8 of 11 (73%) diagnoses were accurate as made by a teledermatologist.

DERMATOLOGY CLINIC VISITS AVERTED

A feature relevant to both referring clinicians and dermatologists are the number of times teledermatology can avert a clinic-based visit with a dermatologist. Issues such as the feasibility of a particular patient or population to attend an in-person visit and geographic concerns, such as the distance or method of travel required to attend a dermatology clinic, can obviously influence these rates. Another factor is the ability of the referring clinician to perform any recommended interventions such as a skin biopsy or application of cryotherapy. The greater the number of interventions that the referring clinician can or is willing to perform based on the dermatologist's recommendations, the less likely the patient requires travel to the site of dermatology care for those interventions.

Store and Forward

Several studies have reported on the number of dermatology clinic visits averted with the use of store and forward teledermatology. The percentage of dermatology clinic visits averted has ranged widely from 13% to 81%.^{8,10,12,15,16,42–54} The average rate

of dermatology clinic visits that were avoided by store and forward teledermatology was 45.5%.

The store and forward teledermatology program initiated by the Veterans Affairs Puget Sound Health Care System warrants particular mention and description.⁵⁵ In what is perhaps the most sophisticated store and forward teledermatology program reported in the literature, the Veterans Affairs Puget Sound Health Care System Dermatology Service has implemented a curriculum for primary care clinicians that includes initial training, continuing education, development of patient care plans, and basic surgery skills training. Between baseline and year 1 of this program, a fairly dramatic change in clinical practice patterns was noted. At baseline, most dermatology care (61%) was referred to the remote dermatology clinics, whereas at year 1, only 15% of the patients were referred to remote dermatology clinics ($P < .01$). This result coincided with an increased number of procedures (eg, biopsies) being performed by the primary care clinicians through the training component of the teledermatology program.

Real-Time Interactive

For real-time interactive teledermatology, the rate of visit avoidance has ranged from 44.4% to 82%.^{42,56–59} The average rate of clinic visit avoidance was 61.5% for real-time interactive technology. These values are higher than those reported for store and forward teledermatology as may be expected because the nature of real-time interactive teledermatology is more commonly meant to function as a substitute for an in-person evaluation, whereas store and forward teledermatology is more likely to be used, in part, as a triage mechanism to decide who does and does not need to be seen.⁶⁰

CLINICAL OUTCOMES

Another referring clinician's question of relevance is how does teledermatology affect the clinical course of patients—would the patients be expected to fare better, worse, or the same if teledermatology is used? Similar to accuracy, assessments of clinical course can be difficult. If you are assessing a single disease and a disease-specific severity measure exists, then such a measure can be used. For example, if the target condition is psoriasis, then a measure such as the Psoriasis Area Severity Index can be used. However, the vast majority of skin conditions have no such instrument available.

Store and Forward

Three randomized trials have assessed clinical course with store and forward teledermatology.^{61–63} Two of these studies were of similar design and used serial digital images as a means of assessing clinical course.^{61,62} Serial digital images were used to assess the clinical course of a wide variety of referred ambulatory skin conditions. Both these studies yielded similar results. In the first study, between the time of referral and month 4, the percentage of conventionally referred patients rated as improved was 65% versus 64% for teledermatology; 32% were rated unchanged for conventional care compared with 33% for teledermatology; 3% were rated worse in the conventional care group versus 4% rated as worse for teledermatology.⁶¹ The differences were not statistically significant ($P = .57$). For the second study, a larger number of categories were used to rate clinical course.⁶² Between the time of referral and month 9, conventionally referred patients and teledermatology patients, respectively, were rated as resolved in 26% versus 25%; improved in 46% versus 47%; unchanged,

not clinically relevant in 11% versus 10%; unchanged, clinically relevant in 13% versus 10%; worse in 4% versus 8%. There was no evidence to suggest a difference in ratings between the 2 referral groups ($P = .88$). A third study randomized patients to clinic-based follow-up or follow-up using smartphone technology to manage facial acne treated with isotretinoin.⁶³ A smartphone was used both to collect the images and to transmit clinical information between the patient and dermatologist. Clinical course was rated using the Global Acne Severity Scale and total lesion count. The severity of acne during 24 weeks of treatment improved in both groups with no evidence for a difference between the 2 management options ($P = .38$ as measured by the Global Acne Severity Scale and $P = .95$ as measured by the total lesion count).

Real-Time Interactive

Two studies conducted a retrospective medical record review of teledermatology consultations to assess clinical outcomes.^{64,65} In one study, of 127 subjects reviewed, 58.3% were rated as showing clinical improvement, 16.5% were rated as no clinical improvement, 7.1% of the patients were rated noncompliant, and 18.1% were rated as not applicable to include chronic conditions that would not be expected to change.⁶⁴ In a second study, clinical improvement, as documented by a teledermatologist in a follow-up visit, was reported for 215 (68.7%) of the 313 patients managed by teledermatology with 2 or more teledermatology encounters.⁶⁵

PATIENT AND REFERRING CLINICIAN SATISFACTION

Reliable and valid instruments have not been developed to assess satisfaction among users and participants of teledermatology. Reports in the literature are primarily composed of evaluations that have face validity. Face validity implies that the questions being asked seem to make a reasonable assessment of the relevant issues or address important features at face value.

Patient Satisfaction: Store and Forward

There are several studies that have assessed the satisfaction of patients who have used store and forward teledermatology.^{15,22,63,66–73} Often, patients have not shown a clear preference for teledermatology or conventional care suggesting that they are satisfied with both modalities. With all things being equal, patients would likely prefer an in-person visit, but all things are not equal. For example, a patient may have no local access to dermatology care or travel may be associated with great difficulty. It is issues such as these, among others, that served as the genesis of telemedicine, including teledermatology. Nonetheless, patients have expressed a high level of overall satisfaction with store and forward teledermatology. This feature and other select comments about the patients' perspective on store and forward teledermatology appear in **Table 5**.

Referring Clinician Satisfaction: Store and Forward

Overall, referring clinicians have reported that store and forward teledermatology is a positive experience, with some exceptions.^{15,66–69,71,72,74,75} The educational benefit is an oft-cited useful feature of the consult process. The feedback, often quicker than through traditional consult processes, lends itself at least to the perception that there is an educational benefit derived from the teledermatology consult content and dermatologist to referring clinician communication. In fact, the aforementioned Veteran Affairs Puget Sound Health Care System store and forward teledermatology program has demonstrated improved dermatology knowledge among primary care

Table 5
User satisfaction: store and forward teledermatology

Reported Positive Features	Reported Negative Features	Overall Satisfaction	Reference
Patient Satisfaction			
Would recommend teledermatology to others	Concern about the patient-provider relationship	42%	Weinstock et al, ⁶⁶ 2002
Satisfied that concerns were addressed	—	4.56 on a 5-point scale	Kvedar et al, ⁶⁸ 1999
Comfortable with use of digital images	Concern about incomplete information transmission	7.4 on a 10-point scale	van den Akker et al, ⁶⁹ 2001
Teledermatology was convenient	Concern about not speaking with a dermatologist	93%	Williams et al, ⁷⁰ 2001
Confidence in teledermatology	Concern about time required to learn about consult results	82%	Whited et al, ⁷² 2004
Preference for teledermatology over in-person care in 66% of respondents	Concern about proper treatment and follow-up	4.1 on a 5-point scale	Hsueh et al, ⁷³ 2012
Referring Clinician Satisfaction			
Would recommend teledermatology	Consult process took too long	63%	Weinstock et al, ⁶⁶ 2002
Found it convenient	Time requirements to generate the consult	—	Kvedar et al, ⁶⁸ 1999
Improved access to specialists	Increased workload	21%	Collins et al, ⁷¹ 2004
Preference for teledermatology	—	92%	Whited et al, ⁷² 2004
Easy to use, would use system again	Uncertain that teledermatology would decrease consult time	—	Ou et al, ⁷⁴ 2008
Educational benefit	Problems with information technology	71%	McFarland et al, ⁷⁵ 2013

clinicians that used the teledermatology referral system.⁵⁵ A dermatology competency examination was administered to primary care providers at baseline and 1 year into the program. Scores on the examination improved from 63% correct to 74% correct at year 1 ($P = .01$).

Negative comments are voiced when the referring clinicians are responsible for generating and sending the teledermatology consults, which is understandable in busy primary care practices and suggests that teledermatology technicians or other staff dedicated to initiate and send teledermatology consults may be important, at least for clinics that would expect to generate a large volume of consults. This concept is analogous to the role that a phlebotomist plays when a blood test is ordered. This particular issue was reported in a study that assessed the perspectives of primary care clinicians who were users of teledermatology, primarily store and forward teledermatology.⁷⁶ A challenge reported by the primary care clinicians was the competing interest and deviation from their usual workflow processes imposed by the generation of the teledermatology consultation. Nonetheless, all surveyed primary care clinicians rated teledermatology as extremely valuable. A summary of other perceptions provided by referring clinicians appear in **Table 5**.

Patient Satisfaction: Real-Time Interactive

As with store and forward technology, patients generally express no strong preference for one modality over the other and generally perceive real-time interactive teledermatology favorably.^{27,32,77–80} Representative findings from the literature appear in **Table 6**.

Referring Clinician Satisfaction: Real-Time Interactive

Only 2 studies have assessed referring clinician satisfaction with real-time interactive teledermatology.^{27,81} As with store and forward teledermatology, a perceived educational benefit was a primary positive comment. Negative aspects, much like with store

Table 6
User satisfaction: real-time interactive

Reported Positive Features	Reported Negative Features	Overall Satisfaction	Reference
Patient Satisfaction			
Teledermatology was as good as or better than clinic-based care for contact with the dermatologist	Lack of hands-on examination	—	Nordal et al, ³² 2001
Teledermatology was as good as clinic-based care	Discomfort with the camera	—	Loane et al, ⁷⁸ 1998
Teledermatology as good as clinic visits	—	88%	Hicks et al, ⁷⁹ 2003
Less travel required	—	91%	Al Quran et al, ⁸⁰ 2015
Referring Clinician Satisfaction			
Educational benefit	Problems with information technology	—	Gilmour et al, ²⁷ 1998
Educational benefit	Consults were time consuming	—	Jones et al, ⁸¹ 1996

and forward consults, were reports that the consults were time consuming. In addition, problems with the quality of the visual and auditory features of the information technology were cited as a negative feature (see **Table 6**).

FUTURE CONSIDERATIONS/SUMMARY

Primary care clinicians who have not already encountered teledermatology are increasingly likely to do so in the future. Understanding the evidence that describes how teledermatology performs in areas that are relevant to the referring clinician and their patients should serve as a basis for informed decision making and planning regarding teledermatology implementation. The evidence to date indicates that teledermatology is comparable in diagnostic reliability with conventional consultations and there has been no evidence to suggest a difference in clinical outcomes with store and forward teledermatology. Any application of teledermatology would be expected to avert some proportion of dermatology clinic visits. The variability of this effect has been wide, in part, because of expectations of the consult process, geography, and the ability of referring clinicians to implement dermatologist's recommendations. Overall, teledermatology is well accepted by patients and referring clinicians; however, satisfaction is lower among referring clinicians who do not have support in place to generate teledermatology consultations. Diagnostic accuracy results have been less definitive, with some evidence indicating that teledermatology's accuracy is inferior to in-person assessments. This area may warrant future consideration as certain skin conditions or lesions may have different accuracy characteristics when reviewed by teledermatology modalities. The teledermatology literature is small, albeit growing, and as a maturing discipline these and other more refined research questions may be important topics for future consideration.

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