Recent trends in teledermatology and teledermoscopy

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ABSTRACT

Teledermatology is a useful alternative where specialized dermatological assistance is not available and has been used successfully to support health professionals in a wide range of settings worldwide, in either an asynchronous store-and-forward format or a real-time video conferencing format. Teledermoscopy, which includes dermoscopic images in the teleconsultation, is another addition that improves remote assessments of pigmented lesions. A more recent variant is mobile teledermoscopy, which uses a smartphone to deliver the same type of service.

Teledermoscopy’s greatest strength may be as a triage and monitoring tool, as it can reduce the number of unnecessary referrals, wait times, and the cost of providing and receiving dermatological care. While face-to-face (FTF) care remains the gold standard for diagnosis, drawbacks of not using FTF care as the primary method can be mitigated if teleconsultants are willing to refer to FTF care whenever there is uncertainty. Teledermatology has generally been well accepted by patients and practitioners alike.

Barriers to the large-scale use of teledermatology remain. Assigning medicolegal responsibility and instituting a reimbursement system are critical to promoting widespread use by medical professionals, while privacy and security features and a mechanism to link teleconsultations to patients’ existing health records are essential to maximize patient benefit. Direct-to-consumer services also need attention from regulators to ensure that consumers can enjoy the benefits of telemedicine without the dangers of unregulated or untested platforms.
Introduction

One of the earliest telemedicine specialties, teledermatology is now integrated into several public health systems [1-3] and has been used to support military personnel on deployment [4], staff on commercial ships [5], and care providers in nursing homes [6]. Teledermoscopy is also increasingly popular, using images taken with a digital dermatoscope or a standard digital camera with a dermoscopic attachment with magnification and polarized light, to show the lesion in more detail. Studies of teledermatology have assessed its usefulness in triage and referral by primary care providers (PCPs), consultation with patients or health professionals in remote or medically undersupplied locations, and monitoring patients with chronic skin conditions [6]. Teledermatology can also be a useful educational tool for dermatologists and other health care providers, who can send an image of a difficult rash or lesion to a more experienced colleague for diagnostic assistance and instruction [7-10].

Teledermatology can be delivered as a real-time video consultation (RT-TD) or as an asynchronous store-and-forward (SAF) service. Mobile teledermatology and teledermoscopy are extensions of these services, where a smartphone is used with or without a dermoscopic attachment, to deliver the same type of service from a pocket-sized device. While RT-TD consultations have the advantage of allowing the teleconsultant to ask clarifying questions and providing direct instructions and education to the patient, the image quality of the video is usually inferior to static images used in SAF consultations. Teledermoscopy in particular relies on SAF technology, as its main usefulness lies in the superior detail and clarity of dermoscopic images over clinical images. In addition, SAF consultations allow the teleconsultant to work at a time convenient to them, which is especially useful for consultations in different time zones.

Methods

We searched the PubMed database for reviews and original articles, restricted to human research published in English between 2015 and 2017. The search terms dermatolog*, dermoscop*, dermatoscop*, teledermatolog*, teledermoscop*, teledermatoscop*, remote consult, and remote consultation were combined in the appropriate method for PubMed. Studies were included if the primary focus was on teledermatology or teledermoscopy; studies focusing on computer-assisted diagnosis or teledermatopathology were excluded.

Results

A 2018 [6] literature review of teledermatology use found that the majority of studies were published in the US, UK, and Europe, with several studies conducted in Brazil, Australia, New Zealand, and Turkey, and fewer elsewhere in the world. Recent studies continue to examine teledermatology for a wide variety of disorders (Table 1); teledermoscopy has been mostly studied for assessing melanocytic and keratinocytic lesions [11-25].

### TABLE 1. Conditions Examined by Teledermatology

| Condition | References |
|-----------|------------|
| Acne      | [26-40]    |
| Acneiform/drug eruption | [1,41-48]    |
| Alopecia  | [32,33,37,39,41,42,44] |
| Benign lesions including nevi, seborrheic keratoses, hemangiomas, and scars | [11-16,19-23,27,32,33,35,38-41,44-46,48-61] |
| Premalignant neoplasms | [15,16,20,22,38-42,46,49,50,52,58,60] |
| Malignant neoplasms | [1,11-22,32,35,38,40,41,44-46,48-53,55-58,60-66] |
| Atypical or dysplastic nevi | [15,16,20-22,24,25,33,60] |
| Papulosquamous dermatoses | [31-36,38,39,41,42,44-48,58,59,67] |
| Dermatitis/eczema | [1,28,31-49,67,68] |
| Inflammatory conditions | [26,27,31,35,45,48,56-58] |
| Infections | [1,26,28,31,32,34-37,40,42-48,56-59] |
| Hair or nail conditions | [26,27,44,49,59] |
| Wounds | [42,44] |
| Other | [1,21,26-29,31,32,34,42,43,46-48,53,57-59,67,69,70] |

Accuracy and Interobserver Concordance

Most studies show comparable diagnostic accuracy between teledermatology and face-to-face (FTF) care [55,64,66,71,72], although 3 earlier studies reviewed by Lee and English [71] found teledermatology either significantly superior [9] or inferior [73,74]. More specifically, Finnan et al [75] reviewed accuracy of diagnosis for skin cancer; most studies showed that FTF consultations were more accurate than teledermatology (67%-85% vs 51%-85%); however, some studies found teledermatology was more accurate.

Interobserver agreement between FTF consultants and teledermatologists ranged from 45% to 96% for diagnosis [33,38,42,48,58,61,67] and 66% to 96% for management recommendations, rising to 80% to 90% for skin cancer.
Other studies have found that interobserver concordance when using teledermoscopy is moderate (Fleiss kappa = 0.52) [16] to excellent (prevalence-adjusted, bias-adjusted kappa = 95) [12], with the exception of very difficult lesions [18].

Triaging

Numerous studies found that SAF teledermatology is highly effective as a triaging tool. It can reduce FTF referrals by 31% to 88%, surgery waiting times, and the number of no-shows at FTF clinics [11,13,14,29,31,32,35,42,46,53-57,64,67,71,76-80], although some studies report no difference in time to treatment [51] or number of secondary referrals [52].

Teledermatology can also improve access to dermatological care in lower income groups, such as Medicaid enrollees in the US [39]. Inclusion of dermatoscopic images also improves triaging decisions, including shorter waiting times and low number needed to excise for both melanomas (1.59) and other skin cancers (1.32) [13,42]. In a study comparing paper referrals without dermatoscopic images to digital referrals including dermoscopy, 43% of patients with benign lesions in the teledermoscopy arm were returned to a PCP without a FTF dermatologist appointment, compared to 1% from the paper referrals arm [16]. Inclusion of dermatoscopic images can also allow more cancers to be booked directly to surgery [16,50,64].

One drawback to the reduced number of patients being referred to FTF appointments is the risk of so-called “unimaged melanomas.” These lesions are not initially noted by the referring PCP but rather discovered by the dermatologist management [58,61,71]. Between referring PCPs and teledermatologists, interobserver diagnostic agreement ranges from 21% to 60% [34,45,46,49,59,65], suggesting that teledermatology provides useful assistance to PCPs who lack specialist dermatological training. Still images can also be combined with video (called hybrid teledermatology); one study found that this improved management accuracy compared to assessments with still images alone (87.6% vs 71.7%, respectively). This may be because the video provides additional information about the patient’s behavior not captured by the referring doctor’s history [27].

An important recent study examined teledermatology interobserver concordance rates in patients with either Fitzpatrick I-III or IV-VI skin types. Concordance between FTF and teledermatology diagnosis and management were the same in both lighter and darker skin groups, suggesting that teledermatology is reliable for diagnosis in patients of all Fitzpatrick skin types [41].

As is the case in FTF dermatology, including dermoscopic images (Figure 1) in a teleconsultation appears to improve the reliability of telediagnoses, reportedly improving both sensitivity (0.93-1.0 with teledermatology vs 0.6-1.0 without) and specificity (0.85-0.97 vs 0.72-0.81) [14,55,64]. While including dermoscopy added 1 to 2 minutes to a consultation, 9 minutes (95% CI 8.3-9.5) with dermoscopy vs 7 minutes (95% CI 6.7-7.6) without dermoscopy, the teleconsultant’s evaluation time was almost the same for both groups, at 1.09 minutes (95% CI 1.04-1.14) with dermoscopy and 1.02 minutes (95% CI 1.0-1.04) without [14].

Figure 1. A dermoscopic image provides greater clarity and detail for melanocytic lesions. [Copyright: ©2018 Lee et al.]
as an incidental part of the FTF examination. With reduced FTF appointments, there is a real risk of these lesions going unnoticed [62,63]. However, the reverse can also be true: one study focusing on aesthetic dermatology concerns also identified 5 skin cancers and 2 actinic keratoses by teledermatology [38].

Cost Effectiveness

While some studies found teledermatology to be more expensive than conventional care, in most studies teledermatology was equivalent or more economical [6,13,14,54,67,71,81,82]. Teledermatology consultations usually took longer than FTF consultations [14,83], but economic benefits for the health system stemmed from fewer FTF specialist referrals, and for patients from reduced travel time, costs, and time away from work and faster delivery of treatments [57,72,77,84,85]. RT-TD is generally more expensive than SAF modalities due to more expensive video conferencing technology and difficulty organizing suitable times for multiple clinicians, but can still be more cost-effective than FTF visits, particularly when the patient lives a long way from specialist dermatology care [26,72]. Cost-effectiveness studies have been limited by addressing only a few economic principles in each study; randomized clinical trials and other studies that include a comprehensive economic evaluation are still needed [77].

In terms of quality of life (QoL), there are relatively few studies about the effectiveness of teledermatology for improving QoL. A 2015 review found that teledermatology does improve QoL due to improvements in disease severity [86], but the only 2 studies comparing SAF teledermatology to FTF dermatology found that teledermatology and FTF care were equally effective at improving patients' QoL [68,86].

User Attitudes

Patient and doctor attitudes to teledermatology are generally reported as neutral to good, with patients in rural areas often more positive than urban areas [26,35,38,52,54,57,59,60,72,82,87-91]. A study in which each participant was assessed FTF, by SAF and by RT-TD found that while patients preferred FTF assessment, they were still generally satisfied with teledermatology, and were evenly divided between preferring SAF and RT-TD [92]. Drivers of patient satisfaction included convenience, less travel, shorter waiting times, lower cost, and good quality of health care [21,26,87,92]. Some areas of patient dissatisfaction with teledermatology include poor follow-up or communication by their referring physician, feeling uncomfortable being photographed, or wishing to directly ask the teledermatologist questions [59,72,87]. Referring health care providers generally found teledermatology easy to use but were sometimes concerned about the service's ability to meet patient demand, technical complications, and an increased workload. Consulting dermatologists were also concerned about the lack of ability to palpate lesions, reliability of teledermatology, legal liability, and financial reimbursement [21,57,80,87-90,92]. A survey of attitudes to teledermoscopy particularly found that 71% of dermatologists surveyed were in favor of PCPs using teledermatology to seek advice, provided there was teledermoscopy training for the PCPs, or in the case of long travel distances or long waiting times [93].

Barriers to Routine Use

There are a number of barriers to the effective use of teledermatology. Reimbursement is a major issue to integrating teledermatology into the health care system, as is defining who is ultimately medically responsible for diagnosis and treatment decisions; these issues are complicated further if the referring doctor and consultant are in different jurisdictions [1,3,72,84,88,94,95]. Privacy and security while transmitting patient images and information are critical, as well as integration into electronic health records for maximum effectiveness [3,42,43,84,94,96]. International standards for encryption and data protection, such as International Organization for Standardization (ISO) standards ISO/TS 13131:2014 on tele-health services [97] or ISO/IEC 27001:2013 on information technology security [98], should be consulted when setting up a teledermatology service. Finally, referring health care providers will require training on what elements of the patient's history are useful to the teledermatologist, appropriate image acquisition, especially how to use a dermatoscope effectively, and on effectively using the selected teledermatology platform [72,84,99] (see example in Figure 2). There are successful models for new services to draw on, including the Dutch health care system, where teledermatology is fully reimbursed and integrated in the health system, with electronic records available to all system users [3]; the teledermatology service of the US Veterans Health Administration [100]; an NGO-led teledermatology service in Toledo, Belize, where a collaboration between the Medical College of Wisconsin and Hillside Healthcare International has addressed technological requirements, training for PCPs, and ongoing adjustments to the service to optimize its usability [101]; and the Australian Tele-Derm National service, which provides consultations and education to rural and remote general practitioners [49].

Mobile Teledermatology and Teledermoscopy

Mobile teledermatology is the use of a smartphone to take and send images and information to a teleconsultant; mobile
Several studies suggest that PCP and dermatology staffs are able to capture good-quality images with a mobile phone [55,58]. Of note, a study of PCPs found they were able to provide mobile teledermoscopy images of similar quality to images taken in a dermatology department despite having little training in dermoscopy [11,15].

Images taken by study participants themselves are generally of sufficient quality for teleconsultations. A study of mobile dermoscopy with instructions on skin self-examination found that the images were generally good quality, with substantial agreement between mobile teledermoscopy and FTF diagnoses (kappa = 0.9), although 22% of participants did not choose to image lesions that were later selected for imaging by the clinician [22]. Similarly, a study of parent-taken images for a pediatric dermatology service found there was good correlation between telediagnoses and in-person diagnoses (82%) [33]. Another study of high school students found that 98% were able to take good-quality overview images of another person, and 66% were able to take in-focus dermoscopic images on the first try [23].

Mobile teledermoscopy is also a useful triaging tool for PCPs, having been used successfully in mass screening events [20], in underserved areas remote from FTF dermatologists [103], and for reducing waiting time for surgery compared to paper referrals [11].

Mobile teledermatology has also been explored as a relatively low-cost way to extend dermatological assistance to rural health services. A study of a service in Uganda and Guatemala, with US-based dermatologists, found that 89% of the teledermatology consultations changed the treatment plan initially suggested by the PCP, with the added benefit of PCPs improving their diagnostic accuracy over the course of the study [44].

Finally, there is an increasing number of direct-to-consumer website- or app-based dermatology services, which can be very popular with patients: a trial of one app for pediatric dermatology found 83% of parents said that, had the app been unavailable, they would have sought FTF appointments with a PCP, an urgent care clinic, or a dermatologist [28]. Review of such services in 2014-2015 found that there...
were up to 29 available to US patients, with some restricting their advice to acne or anti-aging, while others were treating patients for any condition [29, 104,105]. There is also a number of services aimed at pediatric patients [106]. As for general teledermatology, this form of mobile teledermatology can substantially reduce the waiting period to access care, but services are poorly regulated, frequently do not require proper verification of patient identity, and provide little continuity of care or integration with the patient’s official medical record [29,105-107]. However, there are examples that avoid these pitfalls, usually by being associated with a regulated health care provider, such as the Stanford Health Care eCare Direct program [91] or a trial giving direct-to-consumer access to existing members of a commercial health plan [36].

Ongoing Monitoring

One major advantage of mobile teledermatology is that patients themselves may collect images for short-term monitoring, without requiring a FTF appointment. A study of 29 patients found that 97% were able to collect suitable baseline and follow-up images of nevi with a mobile dermatoscope, with a good diagnostic concordance (kappa = 0.87) between FTF consultations and teledermatology [24]. A study of a smartphone SAF service for facial laser resurfacing patients, allowing them to send daily images of their skin to monitor healing after the procedure, found that patients using the service required fewer FTF consultations. As well as detecting any adverse reactions requiring medical treatment, the teleconsultant was able to reassure participants about reactions that were an expected part of the healing process, such as swelling, exudation, or crusting [69]. A randomized control trial examining ongoing monitoring of isotretinoin acne treatment also found that the mobile teledermatology patients had equivalent treatment success and fewer adverse events than the FTF patients [30].

User Attitudes

There are few studies of consumer or professional acceptance of mobile teledermatology and dermoscopy, but existing studies indicate favorable attitudes. Patients generally expressed satisfaction with mobile services, citing improved waiting times, convenience, comfort, reassurance, and privacy [24,30,69]. One study found that a high number of participants believe that mobile teledermoscopy would improve their skin self-examinations for cancer and motivate them to check their skin more often [19], and in other studies parents were willing to use a pediatric teledermatology service for their children [28,33]. Participants generally reported feeling comfortable and competent with taking dermoscopic images after minimal instructions [19,23].

Drawbacks were requiring assistance to image hard-to-reach areas like the back [19], uncertainty about privacy and accuracy [69], uncertainty about completely trusting a telediagnosis [19], and uncertainty about whether insurance would cover such a service [24]. A discrete choice survey of mobile teledermoscopy patients found that patients preferred involvement of a doctor to skin self-examinations, but also strongly preferred having their concerning lesions assessed by a dermatologist rather than a GP, which is more easily achieved via mobile teledermoscopy [108].

There are very few studies of clinician attitudes about mobile teledermatology. A survey of nurses in Arizona, which included an introduction to mobile teledermoscopy, example images, and case studies, found that although most had not used mobile teledermoscopy, they perceived it to have the ability to improve diagnosis and positively affect their practice, with moderate scores for perceived ease of use. However, this study may be influenced by self-selection bias [109].

Barriers to Use of Mobile Teledermatology

While modern smartphones enable patients to take and forward their own images, patient-acquired images have drawbacks such as teleconsultants having difficulty confirming patient identity and coordinating with PCPs [72]. The proliferation of poorly regulated direct-to-consumer teledermatology apps may also have adverse outcomes for consumers who rely on them rather than professional, individual medical advice, particularly where the service relies on algorithms to diagnose or suggest treatment plans, without oversight by a trained health care provider [29,106,107,110].

Conclusions

Teledermatology is a useful alternative where specialized dermatological assistance is not available, and has generally been accepted by patients and practitioners alike. Its greatest strength may be as a triage and/or monitoring tool, in both underserved areas and busy metropolitan dermatology clinics, by reducing both the number of unnecessary referrals and wait times. While FTF care remains the gold standard for diagnosis, this drawback can be mitigated if teleconsultants are willing to refer to FTF care whenever there is uncertainty.

Despite these advantages, barriers remain to incorporating teledermatology into large-scale use. Privacy and security features are essential to any telemedicine system, and teledermatology records need to be linked to patients’ health records for maximum effectiveness. Assigning medicolegal responsibility and instituting a reimbursement system are also critical to persuading greater numbers of health profes-
sionals to use teledermatology. Direct-to-consumer services also need attention from regulators to ensure that consumers can enjoy the benefits of teledermatology without the dangers of unregulated or untested platforms.

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220

Review | Dermatol Pract Concept 2018;8(3):13
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