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Joseph C English III *Editor*

Teledermatology

A Comprehensive Overview

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Updates in Clinical Dermatology

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Teledermatology

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I dedicate this book to the love of my life, my soul mate and my wife, Michelle English. She has been the foundation to my successful career in academic dermatology and supportive of my textbook endeavors ("Hun, just get it done") as well as the architect to raising our family (Joe IV, Jackson, and Magdelyn). My advice to future teledermatologists is that although academic achievements are woven into our DNA, it does not mean much without the love of God and family.

Preface

As medicine and surgery have evolved over time to improve patient care, so have the mechanisms by which healthcare is delivered. It has evolved significantly and explosively, on account of the pandemic of 2020. Despite physical restrictions necessary to prevent the spread of the virus, all other diseases continued to affect mankind necessitating an alternative form of healthcare. Electronic healthcare (telemedicine) came to the immediate forefront as a means to cover this breach of care to our patients. Some providers were prepared, while others started de novo. Dermatology, as a visual field, readily adapted to this dilemma during the shutdown period. The majority of dermatologists maintained their practice by becoming teledermatologists. Though not all continue with teledermatology, it has become an evidence-based format to deliver skin care. Due to the disproportionate ratio of patient to dermatologist, treating the burden of skin disease in the United States is currently not attainable. Teledermatology has allowed a marked increase in access to skin care to those with limited availability to board-certified dermatologists, both in the outpatient and inpatient arena. This textbook is a collection of manuscripts written by some of the current leading teledermatologists, offering a comprehensive overview of teledermatology. The intent of the book is to facilitate the development of future teledermatology programs and enhance existing programs. There are 24 chapters covering the aspects of teledermatology that I consider most important to understand its role in the care and management of skin disease.

Pittsburgh, PA, USA — Joseph C English III

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Teledermatology: Platforms

Allison Dobry, Jocelyn Almanza, and Robert Stavert

Introduction

Teledermatology is the diagnosis and management of dermatologic problems by remote clinicians. There are two principal modalities of teledermatology care delivery: synchronous visits using real-time video and asynchronous visits using digital photos combined with patient information. The simultaneous use of features pertaining to synchronous and asynchronous modalities is known as hybrid teledermatology. Teledermatology care can be provider-to-provider or direct-to-patient. There are numerous types of teledermatology platforms, with some directly integrated into existing healthcare platforms and medical record systems, and others existing as separate Internet and mobile application-based platforms. Teledermatology has the potential to offer several advantages over traditional in-person care delivery, including cost-savings to patients and healthcare systems, improved access to dermatologic expertise, and improved convenience for patients [1]. Teledermatology is continually evolving, and variations in care among teledermatology platforms have led the American Academy of Dermatology to produce an official position statement about best practices for teledermatologists [2]. A dramatic increase in teledermatology utilization occurred during the COVID-19 pandemic due to a reduction in the availability of in-person appointments, expansion in reimbursement for telemedicine visits, and relaxation of technological regulations. Prior to the pandemic, telehealth visits comprised less than 1% of all outpatient visits. During the pandemic, this number soared to 13% and has since stabilized to around 8% as of August 2021 [3]. In this chapter, we will review the most common types of teledermatology platforms and how they operate within our current healthcare infrastructure.

Store-and-Forward Platforms

Store-and-forward (SAF) teledermatology is a delivery model in which either a referring physician or a patient sends health information and a consult question electronically to a dermatologist for evaluation. It is described as an asynchronous modality because SAF does not require real-time interaction by participants. In a typical SAF teledermatology model, photographs of a patient's clinical concern and relevant patient information are uploaded to a platform for a dermatologist to

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review. The dermatologist then can review the submitted information and respond to provide diagnostic and management recommendations to the submitting patient or clinician.

SAF has been shown to have high diagnostic [4] and therapeutic concordance [5], reduce overall costs, increase accessibility, and generate similar outcomes to in-person care in a variety of settings [6]. SAF platforms vary across institutions, and these variations may affect the performance of the model. For instance, diagnostic concordance rates are higher when using clinician-initiated images instead of patient-initiated images [4]. Compared to in-person visits, SAF platforms have also demonstrated equivalent improvements in quality of life and disease severity when used for the management of psoriasis and atopic dermatitis, respectively [6].

Electronic Medical Record Native Platforms

The majority of dermatologists use SAF platforms that are integrated directly into their health systems' electronic medical record (EMR) [7]. One of the most commonly used EMR systems by large healthcare systems in the United States is the Epic EMR software [8]. The integration of SAF into Epic allows referring providers to securely upload patient photos and relevant medical information through the EMR for dermatologists to access. SAF platforms integrated into Epic have been used by many different hospitals and have been shown to have high diagnostic reliability and improve access to dermatologic care [8].

Within a healthcare system, a primary care provider typically submits a consult question to the dermatologist, and the dermatologist provides a differential diagnosis and management recommendations within a certain timeframe. The PCP is then responsible for ordering subsequent diagnostic tests and choosing the therapy plan and can then decide whether to place an in-person referral for additional management. In this model, providers using the same EHR can coordinate care via integrated SAF platforms and PCPs are able to provide continuity of care. The utilization of SAF platforms is more amenable to certain conditions such as acne, psoriasis, eczema, rashes, and lesions of concern [9]. Visit types such as total body skin examinations cannot be reliably performed using teledermatology. SAF platforms are also better utilized for simpler dermatologic cases such as acne management, whereas synchronous platforms may be preferable for complex medical dermatology management that involves the prescription of immunomodulators and biologics [10]. SAF may also be preferred over synchronous platforms for patients with limited Internet or broadband capabilities.

Although SAF teledermatology has been used extensively in outpatient settings, its use in inpatient settings has only recently begun to be explored. The use of SAF teledermatology has been effectively applied in emergency department settings for triage and management decisions [11]. In addition, it has also shown to be reliable in the inpatient setting for initial triage decisions, diagnosis, evaluation, and management [11–14]. However, it has been less optimal in disposition planning, likely given the high complexity of coordination of care, and in-person evaluation may be necessary for this aspect of care [12].

SAF Platforms for Dermatologists and Health Systems

Around one-quarter of dermatologists rely on teledermatology vendors or mobile apps to conduct teledermatology visits [7]. One example of this is Zipnosis™ (Minnesota, US), in which patients can use asynchronous protocols to submit information about their dermatologic concerns [15]. These platforms may offer additional capabilities, like assistance with after-hours messaging and prescription refill requests. Some even offer automated translation services to increase access to non-English speaking populations. An additional advantage of these platforms is that they may have automated tools to reduce the overall administrative burden on physicians, reducing overall time spent on data entry for patient visits. Some teledermatology vendors also offer asynchronous digital health tools not typically part of traditional EMRs. For instance, Miiskin™ (Denmark, EU) offers artificial intelligence-driven mobile applications for mole and acne monitoring. It is unclear whether these additional features improve overall clinical outcomes at this time.

Direct-to-Consumer SAF Teledermatology Platforms

Direct-to-consumer (DTC) teledermatology allows patients to directly consult a dermatologist. DTC teledermatology platforms experienced growth during the COVID-19 pandemic due to the altered regulatory landscape, significant investments, and marketing campaigns. The structure of DTC companies is variable, but they generally fall into two main categories: (1) traditional SAF platforms whereby patients seek expert opinion on diagnosis and management for a dermatologic concern, and (2) prescription-focused in which patients seek access to specific dermatologic prescription medication. DTC companies fill a unique niche to address problems with accessibility and affordability in that many offer a "one-stop shop" for patients to receive a diagnosis, get a prescription, and purchase medication within a 24-h time frame [16]. Some DTC companies such as FirstDerm (California, US) have additional capabilities such as scanning nevi if a patient buys a dermatoscope attachment. Payment models are variable and are only sometimes covered by insurance. Consumers tend to be younger, female, live in higher income or urban areas, and prefer access to care off hours [16, 17].

Within traditional SAF DTC platforms, patients visit company websites or mobile applications to select their dermatologic concern, complete an intake form, and provide photos. Some companies, such as 3Derm™ (Massachusetts, US), have a machine learning-guided image quality detector to maintain high image quality [18]. This information is sent to a clinician, who provides a diagnosis, recommendations, and prescriptions. Given the novelty of this field, there is a paucity of rigorous studies on the standard of care, clinical outcomes, and impact on access for diverse populations. However, this is an evolving area of care with significant potential to increase access to dermatologic care. Companies such as 3Derm have secured funding from the National Science Foundation for their machine learning algorithms.

Several concerns have previously been raised regarding SAF DTC models. Examples of concerns include lack of transparency regarding provider credentials. Quality concerns have also been raised as some DTC companies may fail to collect comprehensive past medical history and struggle to accurately diagnose complex dermatologic conditions. Additional quality concerns, such as a lack of adherence to evidence-based guidelines and poor care coordination, have also been raised [19, 20].

Some companies do not offer prescriptions, some offer prescriptions sent to any pharmacy, and some only prescribe via their own pharmacy. The complexity of prescriptions offered is also variable, and some companies like SkyMD™ (California, US) offer prior authorization support and prescription of biologics.

In prescription-based companies (such as Hims & Hers™ (California, US), Apostrophe™ (California, US), and Curology™ (California, US)), clinicians assess the appropriateness of a specific medication for a patient. Given that many drug patents have expired over the last decade, several DTCs focus on streamlining access to prescription medications by offering easy access to clinicians who can prescribe these medications, which are typically rebranded generic versions that are sold in their own pharmacies [21]. There are several criticisms with the prescription-focused model. The first is the potential for conflict of interest—the process of writing prescriptions and selling medications is typically separate, whereas these companies combine the two, incentivizing writing more prescriptions [16]. Secondly, there is little nuance with regards to managing medications, as these companies are limited to prescribing medications for FDA-indicated diagnoses [22].

Despite the many criticisms of DTC platforms, there is a significant opportunity for increasing access to high-quality care if quality control measures are put into place. Other suggestions for improvement include increased transparency of clinician credentials, more comprehensive medical intake, increased interactivity to collect more relevant information, improved care coordination, and increased adherence to evidence-based guidelines [19]. Many of these problems may be solved by combining SAF teledermatology with an initial synchronous video visit to establish a more authentic patient–doctor relationship.

Ad hoc SAF Teledermatology Platforms

While there are formalized SAF platforms to conduct teledermatology, a large portion of patient–doctor interactions are increasingly being moved to EMR messaging and emails. The structure of this form of digital care is more vague, but still comprises an important aspect of medical care. Physicians can send results and further follow-up instructions via messages, and patients similarly can send a message to their dermatologist with follow-up questions or with a new clinical question altogether. Without referring providers involved, there is no longer one degree of separation between patients and SAF teledermatology systems, and patients can submit clinical information and images at any point in time. Patient messaging is less structured in nature, and patient-submitted images are more frequently inadequate for use in clinical decision-making due to low image quality [23, 24]. A high percentage of dermatologists are unable to comfortably use low-quality electronic data for clinical decision-making and this challenge can be associated with clinician burnout when high volumes of patient-submitted electronic data are being reviewed [23, 25]. While patient messaging has been shown to be useful for monitoring wound healing, its utility for the management of other dermatologic concerns is less clear. Unlike messaging in EMR systems, the use of emails as a medium to communicate with physicians grants patients the liberty to also discuss non-medical topics. Limitations to the use of email are related to medicolegal implications surrounding the appropriateness or urgency of emails sent by patients [26]. Patient messaging is a rapidly evolving field, and some institutions are implementing reimbursements for physicians who conduct clinical care via this medium given the increasing component of clinical time it requires of dermatologists after hours.

Live Interactive Teledermatology Platforms

Live interactive (LI), or synchronous teledermatology, uses video-based technologies to facilitate real-time communication between a dermatologist (or other physicians) and either a patient, caretaker, or another healthcare provider. Unlike asynchronous, or SAF teledermatology models, LI teledermatology requires coordination to ensure that the dermatologist and patient are available at the same moment in time and able to connect via a video-based platform.

Historically, several barriers have existed which have limited the widespread adoption of live interactive teledermatology models. These barriers include the cost of video equipment to facilitate real-time video communication; coordination challenges in synchronizing schedules of participants; uncertain reimbursement; difficulty achieving sufficient video resolution for accurate clinical evaluation; and privacy-related concerns [27–29]. As the cost of platforms facilitating real-time video connection among participants has decreased, and the availability of such platforms has increased, more dermatologists and patients have begun to explore the use of LI teledermatology.

During the COVID-19 Public Health Emergency, many dermatology practices were forced to temporarily close, or to significantly limit typical in-person office visits.

Additionally, changes in reimbursement as well as relaxation of HIPAA restrictions led to a rapid and significant increase in the number of dermatologists offering LI teledermatology visits. These LI teledermatology visits commonly occurred via teledermatology platforms as outlined below.

Electronic Medical Record (EMR) Native Platforms

EMR native platforms are LI teledermatology platforms which are an embedded feature of an electronic medical record. During the COVID-19 Public Health Emergency, many EMR platforms added new functionality to allow dermatologists and patients to connect for LI visits, directly through the EMR. This type of platform offers several advantages. First, because the platform exists within a medical record, providers have access to the patient's medical record, including relevant medications, history, and other supportive information that may be helpful during the consultation. These platforms additionally typically offer a practical benefit of not requiring additional login credentials for the consulting dermatologist. Potential challenges include technological barriers, as patients who have not previously interacted with their electronic medical record online, may in some cases find it challenging to navigate or to login [30]. Additionally, connectivity issues between doctor and patient can arise when there are interruptions in remote access to the EMR.

The table below lists the top five ambulatory EMRs by market share [31]:

1. Epic Systems Corporation 28.21%.
2. Allscripts 9.21%.
3. eClinicalWorks, LLC 6.57%,
4. Athenahealth, Inc. 6.03%.
5. NextGen Healthcare 5.37%.

EMR vendor list demonstrating the top five vendors in the ambulatory EMR market based on 2018 market shares. Data collected by KPMG.

Top five

Each of these EMRs advertises LI telemedicine capabilities as part of their software offering. Additionally, other EMRs which are particularly popular among dermatologists, including Modernizing Medicine's EMA and Nextech, each also offers integrated LI telemedicine capabilities as features of their EMR offering.

Standalone LI Telemedicine Platforms

As the utilization of LI teledermatology and telemedicine have increased in recent years, several companies and vendors have developed offerings to enable dermatologists to connect with their patients through LI platforms. Examples of such companies include Spruce Health™ (California, US), Mend™ (Florida, US), and Doxy.me™ (New York, US). Each of these vendors advertises that their solutions are HIPAA compliant. These platforms offer dermatologists the benefit of providing or supplementing LI teledermatologic care when this capability does not exist within their existing practice model. The use of these platforms has various strengths and weaknesses. Specific features may vary from vendor to vendor or may be customizable for particular use cases. In general, these telemedicine-specific software offerings may simplify the process of connecting patients to providers for LI visits. For example, Doxy.me™ allows dermatologists to send a link to their patients via email or smartphone so that the patient can simply click on the link and enter the LI teledermatology visit. This avoids having to navigate the EMR which may be a technological barrier for some patients. On the contrary, for dermatologists, the use of platforms which are not fully integrated within the EMR may require them to log into multiple platforms simultaneously which can sometimes create technical or connectivity challenges [28, 32]. Additionally, dermatologists wishing to use the EMR to document, order testing and prescriptions, or review clinical history, during a televisit will have to navigate the EMR to perform these functions while simultaneously conducting the teledermatology visit in another platform, which may be a less than optimal user experience [33].

Direct-to-Consumer LI Teledermatology Platforms

The models described above primarily facilitate dermatologists connecting with their own patients, as well as new patients within a particular health system or practice. Unlike those platforms, DTC platforms allow patients to pay directly to engage with a dermatologist for a LI televisit. Many of these platforms have gradually shifted away from LI visits and some have eliminated them altogether in favor of SAF visits. However, some DTC LI platforms still exist. Examples, such as Sesame™ (New York, US) [34], connect patients directly to dermatologists for LI video consultation.

An advantage of these platforms for patients is their potential convenience for patients. Using these platforms does not require patients to navigate a health system and wait for an appointment. Most DTC LI teledermatology platforms accept direct payment, which may enable access for patients who either do not have insurance or who prefer not to use their insurance for the dermatology visit. There are however several disadvantages of a DTC model. First, if documentation of information discussed in the consultation is not directly provided to the patient or patient's primary care provider, the visit has the risk of segmenting care in a way that may prevent patients from getting appropriate care. For example, in most DTC care models, if the patient has a skin condition which raises suspicion for a systemic condition, such as sarcoidosis or systemic lupus erythematosus, there are no mechanisms in place to ensure that the patient gets appropriate follow-up to evaluate for other manifestations of these conditions. A study published in 2016, raised concerns regarding the quality of care provided in some direct-to-patient teledermatology services [19]. While this chapter evaluated primarily SAF services, it highlighted potential risks including uncertain quality of care, and uncertainty regarding the credentials of the telemedicine provider.

Ad hoc LI Teledermatology Platforms

In some cases, dermatologists may use common technology platforms that were not intended for LI teledermatology in order to connect with their patients. This practice became more commonplace during the COVID-19 pandemic, as rules regarding HIPAA compliance and reimbursement for televisits were relaxed. Examples of such platforms include FaceTime™ (California, US) voice and video calling, Zoom™ (California, US), Google Meet™ (California, US) video conferencing system, and Skype™ (Luxembourg, EU). In order to ensure that patients with a concern had an opportunity to be evaluated, providers and patients sometimes reverted to these platforms because of their easy availability and familiarity with use. Prior to the COVID-19 pandemic, use of such platforms for the provision of LI teledermatologic care was generally avoided due to concerns regarding HIPAA compliance and security.

The unique advantages of each previously described modality can be combined using hybrid teledermatology. Patient photos can be uploaded prior to a scheduled video-based appointment for a dermatologist to review. In other cases, digital uploads for asynchronous review can be supplemented with video-based visits, if deemed necessary after dermatologic evaluation. The combination of these two modalities has shown improvements in management accuracy compared to visits relying solely on patient images and relevant histories submitted [32]. Integrating video-based visits may provide additional patient information not initially captured based on the review of digital consults alone and may also allow for real-time clarification of uploaded patient data, potentially avoiding repeat consults [32, 35]. In a survey conducted by the American Academy of Dermatology (AAD) Teledermatology Taskforce, a majority of practicing US dermatologists with teledermatology experience after the COVID-19 pandemic felt that hybridization of asynchronous and synchronous communication had greater accuracy compared to videoconferencing alone [36].

Conclusion

The utilization of platforms for teledermatology is a dynamic and evolving area. Prior to the COVID-19 pandemic, teledermatology was used primarily in niche circumstances. A reduction in the cost of necessary technologies, an increase in the number of available platforms, and changes in regulation and reimbursement prompted by the COVID-19 Public Health Emergency have allowed more patients and dermatologists to experiment with these platforms for the provision of care. The possibility of prompt access to dermatologic expertise from the comfort of one's home offers considerable potential benefits to patients. However, utilization of these platforms in the future will likely be determined by numerous factors, in particular regulation and reimbursement which will significantly influence how practicing dermatologists and health systems design clinical care delivery.

Conflict of Interest Robert Stavert is an employee of Science 37.

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2 Teledermatology: Practice Models

Manan D. Mehta and April W. Armstrong

Introduction

Teledermatology is the use of telecommunications technology to deliver dermatological information and care remotely. Teledermatology can be implemented by selecting an appropriate delivery and practice model that best suits a provider's or practice's objectives. Delivery models include synchronous, asynchronous, and hybrid [1]. Practice models include triage, consultative, and direct care [2]. Additionally, delivery and practice models are not used independently of each other. Instead, they are combined to cater to the clinical practice of a provider or group. For instance, a practice may elect to use teledermatology primarily for triage and choose to use the synchronous method to deliver it. The process flows for each model as well as their advantages and disadvantages will be discussed in this chapter.

Delivery Models

Delivery models are technology dependent and differ in their utilization of technology; however, the role of the dermatologist remains the same for each model: to provide high-quality dermatological care remotely. The most common delivery model practiced in the United States is the asynchronous model, which is also known as the Store-and-Forward (S&F) method [3]. The other two delivery methods are the sy hronous model, also known as the Live-Interactive (LI) method, and the hybrid model.

Asynchronous Model

The asynchronous, or S&F, method involves the patient or their primary care provider (PCP) securely sending the patient's history and images of the areas of concern. For PCPs, this transfer of information is often performed directly through the electronic medical records (EMR) system. For patients, it may be done through dedicated patient portals or even emails, depending on the available infrastructure [4, 5]. Dermatologists then review the provided information at a separate time, upon which they can send recommendations for further diagnostic workup, treatment, or scheduling of face-to-face visits.

Benefits

Asynchronous teledermatology alleviates the challenge of finding a suitable time to meet for both parties. Instead, the patient or PCP can send relevant history and images to the dermatologist at their earliest convenience, which the derma-

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tologist can then separately evaluate as soon as their work schedule allows. This advantage is particularly useful for providing access to rural areas located in different time zones than the dermatologist providing care [1, 6].

Additionally, if a thorough and focused history and high-quality photos are provided, the dermatologist can develop an assessment and plan for patients quicker than the time required for a full face-to-face or live-interactive teledermatology visit [7, 8]. This, in turn, allows for an increased volume of patients to be evaluated and can help alleviate the backlog in high-demand areas where patients may otherwise have had to wait months to be seen by a dermatologist [9]. Importantly, this occurs without compromises in accuracy or reliability when compared to in-person dermatology visits [10]. An earlier diagnosis also allows patients to begin treatment earlier, increasing patient satisfaction. Indeed the S&F method has been shown to cause timelier interventions compared to traditional referrals [10]. For these reasons, patients and dermatologists have been highly satisfied with this method [10–12].

Further benefits of the asynchronous model are especially prominent for those in rural areas, where high-speed connectivity may be limited [13]. For these patients, uploading a high-resolution image is much easier and more feasible than communicating live via videoconference, which requires a greater bandwidth [6]. Videoconferencing in these areas may lead to choppy meetings with blurry images, causing frustration for both the dermatologist and patient.

Lastly, the S&F method possesses lower administrative overhead and equipment costs compared to other delivery models, and thus represents a lower barrier to entry for dermatologists seeking to add teledermatology to their practice [7].

Challenges

The primary challenge with asynchronous teledermatology is the inability for both patients/PCPs and dermatologists to directly clarify parts of the history, diagnosis, or management and ask follow-up questions [6]. Asynchronous teledermatology relies on PCPs or patients sending pertinent positives and negatives alongside high-quality photos, which may not always occur. For example, patients and PCPs may omit key details that they may view as less relevant but may be critical to helping separate diagnoses such as sexual history or the presence of mucosal lesions. This could be mitigated, at least in part, by additional training of PCPs; however, this would increase costs for the hospital. Low-quality photos may also be sent by patients, requiring the dermatologist to request another set of images or needing to evaluate the patient through a live visit, either via teledermatology or in-person. However, studies have shown that providing photo-taking instructions to patients greatly improved image quality [14].

Additionally, even if the providing dermatologist has all the information needed to make a diagnosis and management plan, patients may still have questions or concerns about their diagnosis and treatments. For example, after a new cutaneous diagnosis is revealed, patients may, understandably, have extensive questions to increase their health literacy. Other patients may experience stress from wondering if they are contagious or if they could have done anything to prevent their disease. Additionally, some patients may have concerns before starting their medication or may seek alternatives that better align with their preferences or schedule. Some of these questions may be able to be resolved by the patient's PCPs. However, given 62% of teledermatologists' final diagnoses were discordant with the original PCP's diagnoses, many questions may only be resolved through the depth of experiences and expertise of the dermatologist [15].

In either scenario, further discussion requires the inquiring party to send a new message to the opposite party and wait for a response. Sometimes, this may only resolve after a back-and-forth discussion over the course of days, which may lead to frustrations from both patient and provider due to its inherent inefficiency and delays in care. Additionally, the messages may filter through other personnel like assistants before reaching the provider, which utilizes more hospital resources. Indeed, the cases where teledermatologists found the S&F method to be less efficient than in-person visits was primarily when they had to re-request images or obtain additional history from the referral site [7]. Similarly, referring PCPs using S&F teledermatology cited workflow and communication with dermatologists as areas where they would most like to see improvement [16].

There are also challenges specifically with applications currently available for asynchronous teledermatology, including application cost, ease of use, and compatibility with existing EMR systems [17]. However, these are likely to improve over time.

Synchronous Delivery Model

The synchronous (LI) model consists of real-time videoconferencing between the patient and the dermatologist. Inpatients may have mobile tablets set up by their primary care teams in their room in anticipation of the call, while outpatients may use computers or mobile devices. Notably, modern videoconferencing often occurs through Internet-based platforms in comparison to the past where strict videoconferencing platforms were required [18, 19].

Benefits

The primary benefit of this method is it allows for real-time discussion of the diagnosis and management [20]. This helps save time for patients and providers by avoiding the multiple back-and-forth messaging that is seen with asynchronous method. Providers can discuss diagnoses and treatment options with greater depth and ease compared to the asynchronous method. Direct conversation also provides the opportunity to assuage patient concerns and fears assuaging immediately, which may decrease the urge for patients to read about their condition online, where they may encounter misinformation. At the same time, providers can obtain live patient feedback to help decide a plan that best fits their lifestyle and preferences. This shared decision-making not only ensures the patient is more likely to follow treatment recommendations but also builds trust and confidence from the patient in the provider.

Another advantage of this method is the ability to form an interpersonal patient-physician connection similar to face-to-face visits [21]. By directly speaking with and seeing their dermatologists, patients can begin to develop rapport, which boosts their likelihood of adhering to management plans. For those requiring further workup or management with a face-to-face visit, such as those with suspicious growths, the benefit is even greater as the familiarity between the patient and provider provides comfort in the face of a daunting healthcare system. This sense of familiarity is especially important as these patients may have tremendous stressors coming to terms with their diagnosis or dealing with sequelae of their condition.

Challenges

There remain several challenges to this delivery model, including difficulties obtaining clear live views and the extra time needed to coordinate and run the visit. First, the synchronous model relies on patients having the means of performing high-quality video conferencing. Capable devices with the ability to transmit high-quality audio and video remain expensive, for both providers and patients. Moreover, stable connectivity capable of transferring this data is still not universally found [22]. Once the call is established, there still may be difficulty properly displaying hard-to-reach areas. For instance, patients with lesions on their back or buttocks who are unable to directly visualize their lesions may have difficulty angling their cameras into the correct position or difficulty holding their camera steady. With minuscule camera shifts and corresponding camera refocusing, the dermatologist may spend minutes just to have a small window where they can properly view the lesion of question. This problem can be exacerbated in patients using computer cameras to videoconference, as these devices are less mobile. This contrasts with the asynchronous method, where the patient can spend as much time as necessary to capture a high-quality image which the dermatologist then has immediate access to.

Next, like face-to-face visits, the synchronous model requires extra time and effort to coordinate a suitable meeting time and run the visit, compared to the asynchronous method [20, 23]. For rural patients in different time zones, such coordination is even more difficult. Frequently, additional staff are required to coordinate schedules, on top of the staff already needed during the call. Furthermore, because the history is elicited and examination is performed during the visit, an individual encounter takes longer than an asynchronous visit. Discussions about the diagnosis and management may prolong the visit further; however, this may not ultimately differ significantly from the extra time needed to perform the back-and-forth messaging in the asynchronous method and is often more convenient for both the patient and the provider [21].

Hybrid Model

The hybrid model combines the S&F and LI methods by having images, and sometimes the history, of the lesion provided to the dermatologist before the dermatologist speaks directly with the patient [20]. Because images are sent before the virtual appointment, videoconferencing is not necessary; rather, a phone call can be used, both as a primary method of communication or as a backup if video connectivity is lost.

Benefits

The hybrid model represents a fusion that capitalizes upon the strengths of both asynchronous and synchronous models. Unlike the synchronous model, the dermatologist does not lose efficiency waiting for patients to provide clear and steady views of their concerning lesion. Instead, like the asynchronous model, the dermatologist is sent high-quality images prior to the visit. However, in contrast to the asynchronous model, the dermatologist is also able to have a direct discussion with patients or their PCP, providing quick and easy discourse regarding diagnosis and management. Together, these benefits make the hybrid model very efficient [6, 24].

One advantage that separates this model from the other delivery models themselves is flexibility for the dermatologist to tailor the discussion to distinct aspects of the case that require longer discussion. For instance, for complicated diagnoses such as a systemic connective tissue disease like lupus, the dermatologist can spend a greater amount of time discussing manifestations of the disease and the required multidisciplinary care. Or, if a patient requires systemic therapies, such as biologics, the dermatologist can spend a greater amount of time alleviating concerns patients may have about injections or immunomodulation. This is supported by a recent study that investigated the use of asynchronous and synchronous teledermatology at an academic center. This study found that drugs such as antibiotics and nonretinoid acne medications were more commonly prescribed during asynchronous visits, while biologics and immunomodulators were more commonly prescribed with synchronous visits. Furthermore, since the utility of each model led to an almost even split in preference between providers, the researchers reported their institute decided to implement a hybrid teledermatology model [25].

Challenges

Due to the inherent nature of the hybrid model involving two steps, there is greater up-front setup and training for all staff members involved. Moreover, additional support staff may be required to efficiently manage both processes together compared to synchronous or asynchronous teledermatology alone. This creates additional costs which may pose a greater barrier to entry. Additionally, although the hybrid model alleviates most of the challenges from the asynchronous and synchronous models alone, it still retains some of their drawbacks [20]. For example, the hybrid model still requires finding a suitable time for both patient and PCP to meet with the dermatologist. Nevertheless, the hybrid model retains an overall better disadvantage profile than the other two delivery models.

Practice Models

Practice models are technology independent, allowing them to be implemented through any mode of technology discussed in the delivery models section. Instead, the difference between practice models lies in the main roles of the dermatologist. The triage model is not widely practiced throughout the US, but it can be helpful in providing equitable distribution of dermatologic care and its utilization has been increasing [2]. The consultative model is commonly used within the US, and involves a dermatologist providing diagnostic and/or therapeutic recommendations to the PCP directly caring for a patient. In the direct care model, the dermatologist is the primary provider for the patient's cutaneous disease.

Triage Model

The triage model involves a dermatologist reviewing new cases and subsequently deciding the type of provider, visit type, and timing of care necessary for that condition [2]. In some instances where the dermatologist believes the patient can be managed well by a PCP, the patient remains under the care of their PCP. In other scenarios, where the condition or management may be more complex, the dermatologist may assume the care of the patient. For patients transferred to the care of dermatologists, some may require face-to-face visits, while others can be seen virtually via teledermatology. Lastly, severe or urgent cases may need to be managed rapidly and would be given priority for further evaluation.

Benefits

The primary benefit of the triage model is the proper allocation of scarce resources. Within the US, there remains a significant gap between supply and demand for dermatological expertise. Although approximately one-third of primary care visits in the US are related to skin disorders [24, 26] there are only an estimated 3.4 dermatologists per 100,000 individuals in the US [27]. This discrepancy is further compounded by the fact that most dermatologists are found in urban areas [8]. Even within urban areas, patients face long wait times and fewer than half of dermatologists perform inpatient consultations [28, 29]. The triage model allows health systems to quickly determine the urgency of patients presenting with complex or severe cutaneous conditions and provide equitable care. This gives the highest chance that those that need dermatologic care the most can obtain it. For example, a study investigating the use of the triage system at a university hospital found that 60% of consultations could be seen the next day or later, and 10% could be seen as outpatients [30]. In the outpatient setting, the triage system could help avoid 13–58% of unnecessary visits [2].

Additionally, even in urban areas where dermatologic care is more readily available, implementation of a triage model has led to the added benefit of cost savings due to improved workflow. For example, the implementation of a teledermatology triage model at Zuckerberg San Francisco General Hospital led to savings of approximately $140 per newly referred dermatology patient compared to the conventional dermatologic care model [31].

Importantly, while the triage model produces workflow and cost efficiency, its accuracy remains high [32]. Diagnostic agreement between in-person dermatologists and the triage teledermatologists was found to be close to 83% in one study. Additionally, in less than 5% of cases did the teledermatologist failed to request a biopsy when the in-person dermatologist felt it was necessary [30].

Challenges

Because the triage model is built to categorize patients and allocate them to appropriate level of care, referring providers may be less discriminatory on which cases they send out to dermatologists [33, 34]. Nevertheless, triage systems have frequently been shown to increase both workflow and cost efficiency, as mentioned above.

Consultative Model

In the consultative model, a referring PCP consults with a dermatologist for advice on diagnosing or managing their patient. Importantly, although the dermatologist provides suggestions to the PCP, continuity of care remains with the PCP [7]. Instead, the referring PCP is responsible for counseling the patient, implementing management recommendations, and continued monitoring of the disease course. If new concerns or adverse events arise or if there is a failure to respond to treatment, the PCP may consult the dermatologist further. At that time, the dermatologist may recommend transfer of care to their practice or another dermatologist for further management. However, unless this is done, the patient remains under the care of the PCP and will not regularly follow up with the consulting dermatologist.

Benefits

The consultative method's primary benefit is the expansion of high-level quality dermatologic care and expertise to underserved populations. As mentioned previously, there remains a shortage and maldistribution of dermatologists within the US. These issues create a tremendous amount of skincare disparities which consultative teledermatology has the ability to mitigate. In areas with limited specialist care, the local provider or hospital can consult with the closest dermatologist to provide patients with better dermatologic care [35, 36].

The importance of expanding high-level dermatologic care through the consultative method is underscored by studies that have shown difficulty in referring physicians and hospital ward teams in correctly diagnosing or appropriately managing skin diseases [22, 37]. For example, one study based in a US university hospital found 76.1% of cutaneous diagnosis made by the primary hospital team were changed by the consulting dermatology team. Additionally, the consulting dermatology team made changes or additions to treatment for 77% of patients [37]. Use of this service has led to extremely high satisfaction among referring clinicians, with one study finding 100% of referring clinicians finding the service useful and 97% of them reporting they would use the service again [38].

The consultative model has been also found to help reduce unnecessary face-to-face visits [39, 40]. For example, implementation of a S&F consult program at Cleveland Clinic Health system was estimated to prevent over 350 unnecessary face-to-face visits over a 3.5 year period, saving patients time, money, and travel [40]. Additionally, studies have shown patients receive their diagnosis earlier with teledermatology consults compared to traditional in-person dermatology visits [8]. Importantly, patients treated through the consultative model have been found to have similar diagnostic concordance and clinical outcomes as those treated via face-to-face visits [41, 42].

Challenges

Although the consultative model expands the geographic area dermatologic care can be provided to, it still does not solve the root problem of insufficient resources. Increasing catchment areas through a consultative model can have the potential to overwhelm health systems that may already be operating at max capacity serving their local population. Indeed, despite a 40% decrease in the total number of active teledermatology programs from 2003 to 2011, the annual consult volume was found to have doubled in this same period [33]. However, this potential problem can be and often is mitigated, at least partially, by incorporating a triage system that prioritizes severe, complex, or urgent cases.

Additionally, because patients are not followed by the consulting dermatologist, it is difficult for patients to ask follow-up questions about their diagnosis or treatment plan. This issue is often the patient's biggest concern with S&F teledermatology [43].

Direct-Care Model

The direct-care model allows patients to communicate directly with their dermatologists, either via synchronous or asynchronous methods. In contrast to the consultative and triage models, the direct-care model involves the dermatologist assuming clinical responsibility of the patient [2]. This model is the least utilized practice model but may become more important with continued advancements in the field.

Benefits

Although direct-care teledermatology still requires flexibility in both patient and provider schedules to set up an acceptable meeting time, doing so is considerably easier than in-person visits. This is because patients do not have to budget extra time for travel and are not required to take significant time off from their work. Indeed, despite there being no significant differences in types of referral cases seen with telemedicine and in-person visits, the time between referral and encounter with the dermatologist was significantly shorter than with in-person visits [44]. This increases access for patients who are physically or geographically unable to attend in-person visits.

Additionally, direct care has been proven to work especially well for the management of previously diagnosed chronic inflammatory skin diseases. For example, a study with over 150 adult and pediatric patients with atopic dermatitis found direct access to online care resulted in *equivalent* improvements in clinical outcomes compared to in-person care [45]. Similar results were seen in studies involving psoriasis and acne patients [46, 47].

Challenges

The challenges of direct-care teledermatology primarily arise from limitations inherent to not having physical access to the patient. For example, virtual visits block the ability of the provider to palpate lesions. While patients may be able to report lesions as raised, they may not recognize if lesions are dermal or subcutaneous. Additionally, other tests that aid in diagnosis, such as KOH stains, Wood's lamp examinations, or biopsies could not be performed remotely and would require the patient to come in. This leads to additional visits, which mitigates the benefit of the virtual visit. These physical limitations may explain why many dermatologists feel full-body examinations, melanocytic lesions in high-risk patients, lesions in the hair-bearing area, and patients with diagnosis of melanoma requiring in-person counseling are less suitable for this method of teledermatology [7].

Conclusion

Overall, there are several different practice models and delivery models that a provider or group can choose to best serve their patients. These methods are used in a variety of practice models and patient populations however are most often used by hospitals for rural or indigent patient populations [7].

Choosing an appropriate delivery or practice model is an integral part of implementing a successful teledermatology program. To do so, one must consider the population they are intending to serve and the purpose they are creating this system for, as well as the inherent benefits and drawbacks of each. Importantly, regardless of which practice or delivery model is chosen, it is critical patients know who is evaluating their images, both in terms of identification and qualifications. It is also vital that all models ensure privacy of patient information, photos, and records if they are to be used [48].

There are also additional aspects to consider when choosing between models, including but not limited to costs and reimbursement, implementation, and regulation/ medicolegal issues. In fact, several studies showed reimbursement was viewed as the largest challenge by dermatologists in implementing/maintaining teledermatological practice [7, 49]. Reimbursement and other challenges are further discussed in forthcoming chapters.

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3 Teledermatology: During the COVID-19 Pandemic

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National Expansion of Telehealth in Response to COVID-19

In the United States, the COVID-19 pandemic led to policy changes that significantly expanded telehealth coverage, propelling increased teledermatology utilization nationwide. Stay-at-home orders beginning in March of 2020 halted nonessential visits and closed outpatient dermatology offices, and telehealth emerged as the critical modality to maintain care access while minimizing COVID-19 exposure risk [1–3]. Recognizing the need to promote telehealth mobilization, the Centers for Medicare and Medicaid Services (CMS) enacted policy changes on a temporary and emergency basis to improve public access to telehealth services. Major changes under the Coronavirus Preparedness and Response Supplemental Appropriations Act, 2020 and Section 1135 waiver authority included reimbursement parity for synchronous telehealth, elimination of geographic and originating site restrictions, removal of HIPAA noncompliance penalties for telehealth services provided in good faith, and flexibility for clinicians to waive cost-sharing and conduct new or established patient visits for telehealth paid by federal healthcare programs [4, 5].

These temporary policy changes significantly broadened the scope of reimbursable telehealth. Prior to these measures, geographic restrictions limited telehealth coverage to beneficiaries residing in federally designated rural areas, and originating site restrictions required beneficiaries to travel to certain qualifying sites such as a physician's office or health facility to receive telehealth services [5]. Moreover, lack of telehealth payment parity with in-person visits significantly limited the adoption of telehealth by dermatology practices [6]. With these changes, beneficiaries could now receive covered telehealth services from all areas of the country and from all settings of care, notably from their own homes, and clinicians would be reimbursed for synchronous telehealth visits at the same rate as in-person visits. In addition, relaxation of HIPAA compliance standards meant that in a time of strained health system resources and urgent health care need, everyday communication technologies such as Skype and FaceTime could be quickly mobilized to connect patients with clinicians [7]. The Consolidated Appropriations Act of 2022 extended these temporary measures after the end of the COVID-19 Public Health Emergency, which after several renewals, is currently set to expire May 2023 [8, 9].

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These policy changes broadening telehealth coverage for Medicare beneficiaries paved the way for increased coverage of telehealth services by other payers. During the public health emergency, all 50 states and the District of Columbia took various actions to expand live video telehealth coverage for Medicaid beneficiaries, and a majority of states dropped restrictive geographic requirements and originating site requirements [10, 11]. In addition, many private health insurance companies took action to expand telehealth coverage, and several states mandated temporary parity in covered services or payment with in-person visits [12, 13].

As a result of these changes, academic medical centers and private practices across the nation rapidly mobilized resources to conduct teledermatology visits. According to a survey of member dermatologists of the American Academy of Dermatology, where only 14.1% of dermatologists used teledermatology pre-pandemic, 96.9% used teledermatology during the pandemic [14]. A study of websites and social media accounts of dermatology practices in the United States found that 87% of private practices offered teledermatology by April 2020, with 43% indicating video visit availability and 49% not specifying the telemedicine format [15]. Ambulatory practices at the Yale School of Medicine swiftly developed departmental algorithms for patient triage and trained physicians and staff in protocols to transition from an exclusive in-person practice to a synchronous teledermatology-based model over the course of 3 weeks [16]. Among dermatology clinics affiliated with Massachusetts General Hospital, from April 2019 to April 2020, teledermatology visits increased from 166 to 1957 visits and in-person visits decreased from 7919 to 67 visits [17].

Effectiveness of Telehealth During COVID-19

Pre-pandemic, teledermatology had been widely studied and growing model of care delivery, with multiple studies demonstrating teledermatology's high clinical utility and efficacy [6]. In addition to being clinically effective, evidence suggested that teledermatology can increase access to high-quality dermatologic care and decrease patient travel times [6]. During the COVID-19 pandemic, teledermatology continued to deliver effective and efficient care, and served especially vital roles in care triage and care reallocation [7, 18]. Teledermatology helped limit in-person visits for conditions requiring in-office evaluation thus allowing patient concerns to be stratified according to acuity, decreasing wait times, and improving practice efficiency while mitigating transmission of COVID-19 [19–21]. At the Ohio State University, a teledermatology triage algorithm was successfully implemented to prioritize in-patient dermatology consults, limiting unnecessary in-person encounters and conserving limited hospital personal protective equipment supplies [22]. At the University of Pittsburgh Medical Center, teledermatology was highly effective in treating patients, and less than 5% of teledermatology visits resulted in the need for an in-person follow-up, leading to a marked reduction in unnecessary exposures [21]. One study reported that a majority of established oncodermatology patients remained stable or improved with teledermatology follow-up; however, another found that teledermatology led to inadequate or inaccurate assessment of a substantial proportion of new malignant lesions, leading to a delay in care [23, 24]. Overall, studies support that teledermatology was most effective in triage for chronic inflammatory skin conditions, such as acne and nonspecific dermatitis, as visits for these conditions were most likely to lead to a recommendation for discharge or teledermatology follow-up. Teledermatology was less effective for visit types such as total body skin examination or lesion of concern which was more likely to require in-person follow-up for reevaluation and biopsy [14, 16, 25].

Importantly, patients and physicians were highly satisfied with teledermatology during the COVID-19 pandemic. A survey of 548 patients seen at the Department of Dermatology at Yale School of Medicine reported that most patients felt that their teledermatology visit was easy to set up and had good video or picture quality.

Patients believed that they were able to receive the same quality of care via teledermatology as compared to an in-person visit [26]. Moreover, patients appreciated that their telehealth appointment was time-saving, did not require transportation, and allowed maintenance of social distancing [27]. A survey of member dermatologists of the American Academy of Dermatology reported that a majority of dermatologists were satisfied with the quality of care provided via teledermatology and intend to continue teledermatology after the pandemic [14]. One study at a large academic medical center found that teledermatology had significantly lower no-show rates as compared to in-person visits, especially among minority patients, which suggests that teledermatology may help mitigate barriers to care access [28].

Synchronous and Asynchronous Teledermatology During COVID-19

Telehealth reimbursement parity with in-person care was limited to visits utilizing two-way video or audio formats, causing synchronous teledermatology to become the predominant and default model of teledermatology [19]. The advantage of synchronous teledermatology is immediate patient–physician interaction, which allows for discussion and clarification of issues in real time. During the pandemic, dermatologists appreciated how synchronous teledermatology allowed for improved patient–physician interaction and patient education, and many patients believed video visits to be adequate substitutes for in-person visits [21, 27]. Due to enhanced patient-physician discussion, synchronous teledermatology may be best suited for complex medical dermatology, when in-depth history taking is necessary [21]. During the pandemic, challenges of video visits included patient difficulty in using devices to visualize their skin and technological difficulties such as poor video image quality, Internet service disruptions, and video or audio lag [26, 29].

In contrast, asynchronous teledermatology, commonly referred to as store-and-forward, involves patient sharing of digital photographs for the dermatologist to review at a different time and location. Advantages of asynchronous teledermatology include the potential for superior image quality and increased convenience and flexibility as the need for patient and physician co-availability is eliminated. Limitations include inadequate physician–patient relationships, inconsistent follow-up communication, and suboptimal photo quality. Pre-pandemic, asynchronous models were the predominant model of teledermatology [30]. However, asynchronous models were not included in the telehealth reimbursement expansion and as such, they did not experience nearly the level of utilization as did synchronous models. Nevertheless, asynchronous teledermatology demonstrated high clinical utility during the pandemic for optimal care evaluation and triage [21]. An asynchronous direct care pilot was successfully implemented for isotretinoin management for established patients, freeing in-person and synchronous teledermatology visits for more urgent concerns. Multiple studies suggest asynchronous teledermatology to be especially well-suited for chronic disease management requiring frequent follow-up visits [17, 19, 31]. One study of asynchronous photo triage with dermoscopy found that dermoscopy improved clinician diagnostic accuracy, increased urgency scores of malignant neoplasms, and reduced urgency scores of non-neoplastic or benign neoplastic lesions [32].

Several academic and private practices adopted a hybrid model of teledermatology, involving video visits supplemented with photos to improve assessment [16, 21, 33]. Hybrid models can help overcome the disadvantages of synchronous and asynchronous formats alone by combining high-quality photos with the improved patient–physician interaction of video visits [34]. The implementation of hybrid teledermatology at a large group practice during the pandemic decreased wait times for in-person referrals by 29.6 days as additional in-person appointments were made available [33]. In addition, one survey indicated that a majority of dermatologists believed the hybrid model to have the greatest accuracy [14]. Reimbursement expansion was an important boon for synchronous teledermatology; however, its prioritization may have led to missed opportunities for optimization of efficiency and workflows in scenarios where asynchronous teledermatology or supplementation with high-quality photos would have been better-suited [19].

Teledermatology Accessibility Challenges During COVID-19

Telemedicine was indispensable for care access during the pandemic and has been associated with decreased follow-up times and increased visit completion rates [35]. However, virtual care was not equally accessible for all patients. Evidence suggested that while telemedicine has the potential to mitigate health disparities in certain settings, it can unexpectedly exacerbate health disparities in others [35, 36]. Vulnerable patient populations including those of lower socioeconomic status, older age, and non-English speaking status faced significant barriers to participate in virtual care, especially with synchronous modalities [19, 36, 37]. One study from Beth Israel Deaconess Medical Center reported a 28% reduction in the percentage of elderly patients and a 57% reduction in the percentage non-English speaking patients seen via teledermatology in April 2020 compared to in-office just before the pandemic. Among pediatric teledermatology visits at an urban academic outpatient clinic, Spanish-speaking patients represented 5% of the scheduled appointments during the pandemic, compared to 9% prior to the pandemic [38]. Barriers facing older and non-English speaking populations may include limited technological proficiency, hesitancy with virtual platforms, lack of an email address, and difficulty mobilizing a translator service [25, 38].

Teledermatology access is challenging in areas with higher rates of poverty due to Internet bandwidth and equipment requirements. The well-described digital divide describes how access to broadband Internet and devices correlate with socioeconomic status [36]. In 2021, a survey by Pew Research Center indicated that 24% of adults with annual household incomes below $30,000 do not own a smartphone and 41% do not own a desktop or laptop computer. Forty three percent of lower income adults do not have access to home broadband Internet [39]. In addition, inconsistent teledermatology quality standards may disproportionately affect resource-limited populations [36]. As teledermatology continues to grow in popularity, it remains important that physicians anticipate and address accessibility challenges to mitigate these disparities. Proposed efforts include patient education on telemedicine, technical support staff for practices, device lending or financial assistance, and greater use of store-and-forward teledermatology which requires reduced Internet bandwidth [36].

Teledermatology Post-Pandemic

Teledermatology proved critical in delivering care while limiting travel and exposure during the public health emergency. However, rapid telehealth adoption has also made evident its limitations and the understanding that telehealth cannot supplant many in-person visits. Important limitations of virtual care include the inability to perform a full physical exam, conduct procedures, and administer certain treatments. Technical complications, poor quality photos and video, and limitations of virtual platforms may limit the efficacy of appropriate virtual care [22]. Risks relating to information security, privacy, and medicolegal liabilities will need to be addressed to ensure that teledermatology facilitates safe and secure care for all involved parties [40]. In addition, telehealth visits and documentation may be more time-consuming for dermatologists and contribute to burnout [41, 42].

Despite these challenges, teledermatology flourished during the pandemic as practices adapted and innovated to meet patient care needs during a resource-strained period. Surveys indicate that both patients and physicians were highly satisfied with teledermatology, and both plan to continue teledermatology use post-pandemic [14, 31, 34]. The volume of telemedicine visits has anecdotally declined significantly since the height of the pandemic, however telemedicine visits are unlikely to return to pre-pandemic levels as patients and physicians have adjusted to a new normal [43]. Even with reopening of clinics and greater availability of in-person evaluations, dermatologists feel comfortable managing conditions, such as acne and eczema virtually, suggesting that teledermatology will likely play a permanent role in the management of common dermatoses [44]. Telemedicine has demonstrated success in improving care triage, reducing waiting times, and lowering barriers to care, and it is poised to serve in these critical roles to continue to improve access to dermatologic care post-pandemic [6, 35].

Moving forward, one of the biggest challenges facing teledermatology is sustainable reimbursement [45]. The pandemic reimbursement expansion was key in triggering a surge of telehealth implementation to unprecedented levels; however, limited and restrictive reimbursement policies have long hindered teledermatology adoption pre-pandemic. As many of the policies were passed on a temporary and emergency basis, absent permanent changes to telehealth coverage, though Medicare and Medicaid have promised coverage through 2024, many patients may lose coverage of telehealth options after the end of the public health emergency and face a so-called telehealth cliff [43, 46]. Physicians, patient advocates, payers, and policymakers will need to work together to address the challenges of reimbursement, HIPAA security, and medicolegal liabilities to guide policy decisions on how to best regulate telemedicine post-pandemic. In addition, greater training, technological support, and adoption of best-practice guidelines will help facilitate high-quality teledermatology [18]. Teledermatology has certainly dramatically changed care delivery and proved indispensable during the pandemic. Pending policies regulating teledermatology in the long term, teledermatology is poised to continue playing a prominent role in patient care.

Conflict of Interest None.

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4 Teledermatology: Access and Equity

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Introduction

Access and equity are fundamental challenges to the American healthcare system. In a wide-ranging study comparing the performance of healthcare systems across 11 high-income countries, the US ranked last in terms of access to care which includes measures of *affordability* and *timeliness* [1]. Additionally, despite spending far more of its gross domestic product (GDP) on healthcare than all other high-income countries, *the US healthcare system scored last in equity*; consistently demonstrating the largest disparities in care between high- and low-income groups [1].

Barriers to Access

Telehealth has the potential to expand access or further disenfranchise patients with limited resources and education. In low-income communities, apart from less prevalent medical services, social and financial stressors, such as the inability to take time off from work, lack of child and elder care, and inadequate transportation are significant barriers to accessing healthcare. These socioeconomic challenges may be mitigated with the use of telemedicine [2, 3].

Conversely, telemedicine also has the potential to decrease access to these same vulnerable populations, given that they often have lower rates of digital literacy, Internet access, and smart-device ownership [4]. Accordingly, patient portals that are used for telehealth visits have historically had poor enrollment among low-income, skin-of-color, and non-English-speaking patients [5, 6].

The arrival of COVID-19 ushered in the abrupt and widespread adoption of telemedi-

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cine. Almost immediately, it was evident that the use of telehealth looked very different in affluent and poor communities [7, 8]. This disparity was clearly demonstrated in a study by Uscher-Pines et al., investigating telehealth usage during primary care encounters in safety-net hospitals in California during the pandemic [9]. Before the pandemic, the use of telehealth in any form was extremely limited. Beginning in March 2020, widespread lockdowns due to COVID-19 led to a dramatic increase in virtual visits, replacing the majority of in-person visits. However, virtual visits in safety-net facilities were predominantly audio or "telephone-only" visits while video visits were rarely performed. This was in stark contrast to telemedicine usage in more affluent, middle-class communities and private practices, which primarily consisted of video visits [8]. While other specialties may be relatively functional using only audio communication for remote care, a lack of visual imagery via video or photography in dermatology would inevitably confound the optimal diagnosis and management of cutaneous disease.

Viability of Telemedicine in Vulnerable Populations

Simplified Methods of Connectivity

Given these limitations, it is necessary to understand if teledermatology is truly a viable method of care delivery for vulnerable populations, and whether the integration of telemedicine can increase access to care for patients in under-resourced settings. To study the differential usage of video and audio during teledermatology encounters in a low-income community, Cline et al. quantified platform utilization during televisits in an outpatient dermatology clinic at a safety-net hospital in Brooklyn, New York [10]. Two approaches were compared for video visits: a Health Insurance Portability and Accountability Act (HIPAA) compliant text messaging platform (which did not require patient preregistration or email) and the hospital's patient portal. Of note, patients were only provided the option to video conference via text message after they failed to show up on the hospital's patient portal for their appointment.

The study found that only 10% of patients chose to or were able to video conference via the patient portal, while 56% of patients used the more simplified approach of a text message link [10]. The remainder declined or were unable to video conference through either mechanism. Furthermore, the use of text message-enabled video conferencing was significantly higher than patient portal usage across all genders, age ranges, demographics, languages, and insurance classes [10]. These findings demonstrate that inadequate digital literacy is a significant barrier to the productive use of teledermatology in low-income populations.

As illustrated in Fig. 4.1, participating in a video visit through the patient portal requires several additional steps compared with video conferencing via a text message link [10]. To engage in a video visit through the portal, patients first need to retrieve an access code from the hospital, download a mobile application to access the portal, register for an account using an email address, as well as generate, and remember a password. In contrast, video conferencing via a text message link consists of substantially fewer steps, with no accompanying email or registration requirements. The additional points of friction associated with patient portals likely explain the significant drop-off in the number of video visits completed through this modality. Clearly, effective use of the patient portal requires a much higher level of English language and technological proficiency than video conferencing through a text message link. However, the fact that a majority of patients participated in a video visit even after they neglected to use the portal indicates that patients are amenable to engage in teledermatology, but prefer simpler methods of connectivity [10].

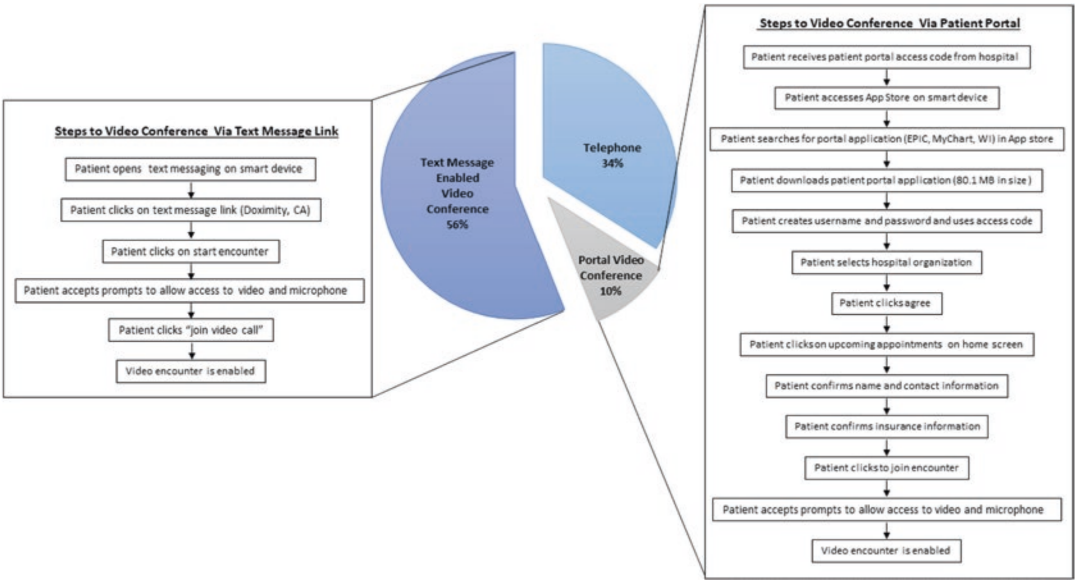

Fig. 4.1 Communication platform usage during telemedicine encounters. The flowcharts depict the steps to engage in a video call for each platform via smartphone. Patients amenable to video participation but unable to connect via patient portal were subsequently sent a text message video link. Reprinted from J Am Acad Dermatol, 85(2): Cline A, Kim C, Berk-Krauss J, et al. Bridging the digital divide: The use of text message-enabled video in the public safety-net setting. Pages e97–e99, Copyright (2021) [10]

Increasing Access to Care

Apart from feasibility, it is necessary to understand the effect of teledermatology on clinic performance. A well-recognized measure of performance and access can be found in the clinic's no-show rate [11]. "No-shows" occur when patients fail to attend scheduled appointments without prior notification to the healthcare provider. Such empty time slots negatively impact healthcare delivery, cost of care, and resource planning [12]. High no-show rates are associated with worse outcomes, and longer wait times to see a physician. From a global perspective, the US is again a significant outlier in terms of its enormously high spending (as a percentage of GDP) coupled with the low performance of the healthcare system compared to other wealthy nations [1]. These missed appointments are a particular challenge in Federally Qualified Health Centers (FQHCs) community centers and safety-net systems, given that low-income and Medicaid patients traditionally have the highest no-show rates [11]. In these facilities, no-shows for scheduled dermatology visits can commonly approach 35% or more [3].

Effect on Clinic Performance in the Safety-Net

Encouragingly, in a study quantifying the comparative no-show rates in an FQHC before and after the integration of telemedicine, it was found that a program comprised of both in-person and televisit appointments was associated with a nearly 40% reduction in no-show rate and a corresponding increase in the total number of completed visits compared with exclusively in-person encounters in 2019–2020 [3]. Importantly, there was no significant difference in patient demographics, most common diagnoses, and languages spoken during the respective time periods. This suggests that the introduction of telemedicine did not alter the patient population normally treated by the clinic and that virtual care has the potential to improve clinic performance in certain settings.

Special Populations

Minority Populations

Minority, low-income patients disproportionately experience challenges in accessing quality dermatologic services [13]. Teledermatology may mitigate some of these disparities, especially given the rising prevalence of smartphones across a wide range of demographic groups [14]. In 2019, 80% of Black, 82% of White, and 79% of Hispanic Americans owned a smartphone [15]. Additionally, Black and Hispanic patients are more likely to use their phones to research health information, suggesting that smartphones may help bridge certain healthcare access inequities [14].

Store-and-forward teledermatology has demonstrated efficacy in improving access to high-quality care for minority patients in safety-net hospitals. A study conducted out of the University of Massachusetts Memorial Medical Center comparing no-show rates for in-person visits in 2019 and televisits in 2020 found that attendance increased among Black, Latin American, and non-English speaking patients [11].

Teledermatology can also facilitate the delivery of culturally competent care. It has been reported that patient satisfaction increases in visits with racial/ethnic concordance between patient and physician [14]. Nonetheless, unequal representation in medicine and dermatology limits regional availability of minority physicians to match patient volume. Teledermatology might address this deficiency by increasing patient access to providers with similar racial and cultural backgrounds [14, 16].

Non-English Speakers

Health centers with large immigrant populations are tasked with an additional challenge when implementing telemedicine for patients with limited English proficiency, particularly in dermatology [17]. Given the visual nature of dermatology, examination of the skin has often pivoted toward store-and-forward photography, which requires not only additional infrastructure but also a non-trivial degree of technological literacy. To participate in photo-sharing, patients routinely need to download hospital-approved telemedicine software, navigate the online medical record, and follow instructions to submit quality skin photographs, which is all the more difficult in the presence of language discordance [18].

Linggonegoro et al. noted higher rates of missed dermatology virtual visits in Spanish-speaking patients compared with English-speaking patients, as well as delays in connecting to interpreter services during virtual visits because of logistical challenges [18]. Their recommendations to better accommodate patients with limited English proficiency include verbal communication, written communication, visit reminders, and instructions delivered in the patient's preferred language (Table 4.1).

Pediatric Dermatology Patients

Pediatric dermatology encounters often have some of the highest no-show rates in ambulatory care [19]. These patients have the additional constraints of school hours and childcare arrangements, on top of the inherent barriers to access in poorer communities touched on previously. Importantly, it has been demonstrated that nonattendance is again highly correlated with insurance class, with uninsured patients and Medicaid recipients most likely to miss their appointments [20]. Since the majority of patients treated by safety-net hospitals are either covered by Medicaid or have no insurance, no-show rates can easily approximate 45% [19]. In a multicenter retrospective analysis of three safety-net hospital clinics, the use of telemedicine for pediatric dermatology encounters was associated with a statistically significant reduction in no-show rates, from 46% to 35% for pediatric dermatology encounters at all sites, despite differing approaches used in the implementation of telemedicine [19].

Table 4.1 Potential communication barriers to telemedicine care for patients with limited English proficiency and proposed best practices

Type of communication	Barriers	Proposed best practices
Written communication	Telemedicine has led to increased use of written communication. The default language for online medical record, emails, instructions for store-and-forward photo-taking and uploading, and text messages is English	Adapt all forms of written communication to patient preferred language
	Varying levels of written literacy	Consider visual tutorials such as video or infographics
Verbal communication	Patient preferred language may not be accurate in online medical records	
	English-speaking family members may make appointments on behalf of the patient	Ask all patients and caregivers whether they need interpreters
	Caregivers with limited English proficiency with children who are fluent in English	
	Default language for phone call reminders and instructions is English	Deliver this information in patient preferred language

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Elderly Populations

Teledermatology can increase access for patients 60 years of age or older, who may otherwise struggle to get in-person care [21]. Elderly individuals may have limited access to transportation services and impaired mobility, causing considerable practical and economic challenges in accessing dermatological services [22]. A retrospective cohort study involving 6633 patients found that the use of teledermatology abrogated the necessity of in-person visits in two-thirds of cases [23].

However, limited digital literacy and smart-device ownership may pose specific challenges in this population. Simpson and Kovarik proposed strategies to optimize engagement in telemedicine for older patients [24]. Their suggestions, outlined in Table 4.2, include offering the option of “audio-only” visits, reducing technological hurdles to connect with the provider, and providing clear and concise stepwise instructions. Nonetheless, despite best efforts, it was found that patients age 65 and older were half as likely to use video and/or photo-sharing as their younger counterparts in a direct-to-patient teledermatology study in a low-income population [25]. As such, telephone-only visits remain extremely valuable in this demographic, and adequate reimbursement is essential to sustain this option.

Rural Populations

Urban areas have 40 times the concentration of dermatologists per 100,000 citizens as do rural areas, and measurable consequences have been reported from this disparity [26]. Hundreds of rural counties in central and western regions of the US have no local dermatologists, with many patients forced to travel over 200 miles to address their skin concerns [27, 28]. Additionally, these patients are more likely to be older and impoverished, further compounding the disparity in access.

Teledermatology has shown great promise for increasing access to dermatology in rural communities both in the US and globally. The University of Missouri has been providing teledermatology services through the Missouri Telehealth Network to expand access for rural Missourians for over 20 years [29].

In a study by Chen et al., store-and-forward teledermatology consultations were found to significantly decrease the need for in-person care in rural California [30]. Of 429 pediatric patients,

Table 4.2 Suggestions for optimizing virtual care for older patients

Suggestion for optimizing care	Helpful tips
Present all available options[a]	• Do not assume a patient's age will dictate willingness or ability to engage in virtual care.-Many older patients are familiar with video chat • For patients uncomfortable with a live video visit, consider digital photographs complemented by telephone discussion•For those without internet/smartphone access, telephone-only encounters can still be effective
Reduce the steps to connect	• Ensure there is a simple workflow alternative • Avoid apps that require patients to sign up for an account and enter excessive information • Look for telemedicine platforms that can be accessed directly within browsers patients may already use • Send invitations at the appointment time via text message or e-mail containing a direct link to the encounter
Provide clear, step-by-step instructions	• Swap ambiguous/technical jargon for descriptive terms • More words or pictorial instructions may be required, because this leaves less room for missteps. • A brief demonstration video or screenshots can also be helpful.
Offer a trial run	• Trained staff members familiar with the platform can prepare patients for virtual visits • Briefly testing the platform in advance of the appointment will build patient confidence and prevent technical delays during live virtual visits
Encourage ergonomic device use	• Larger touchscreen tablets can make visual acuity less of a barrier • For those with limited dexterity or tremor, a mounted webcam that can be detached may be better than a handheld device • Encourage use of speakerphone, which frees the patient's hands to write down recommendations
Use multiparty encounters	• Use teledermatology platforms that permit simultaneous communication between more than 2 parties, so older patients can conduct virtual visits with a trusted advocate. •Advocates may offer assistance with historical information and record treatment instructions

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[a]No matter the platform used, patient privacy and data security should remain a priority, and limitations of these methods should be discussed with the patient

only 1.4% required a subsequent teledermatology appointment, and 6.0% required an in-person visit. Another study out of Brazil involving over 30,000 patients showed that teledermatology could be used to triage patients' skin conditions without the need for an in-person consultation 57% of the time, leading to a 78% decrease in wait-time for an in-person dermatology appointment [31]. Finally, a systematic review found that teledermatology programs were complementary to conventional dermatologic care and increased access for patients living in rural areas with a shortage of dermatologists [32].

Indian Reservations

American Indians have historically had several impediments to accessing dermatologic care. A study in 2018 found that on average, rural Indian Health Service (IHS) centers were 68 miles from the nearest dermatology clinic [33]. Additionally, of the 27 dermatology clinics in closest proximity to rural IHS or tribal hospitals, 22% did not accept patients with Medicaid, and 22% did not accept IHS referrals for patients without insurance. Of established teledermatology programs as of 2018, only 20% had partnerships with an IHS or tribal hospital. Before the pandemic, only 9% of the 303 rural IHS facilities in the continental US reportedly received services via teledermatology [33]. The adoption of virtual dermatologic care could significantly improve access for these communities.

Incarcerated Patients

Given the complexity of coordinating patient–physician interactions for prison populations, there is limited access to dermatologic care for the incarcerated [34]. Since 2003, the University of Utah dermatologists have provided both in-person visits and synchronous teledermatology visits for incarcerated patients [35]. At the discretion of primary care clinicians at the prison, patients are triaged to either teledermatology or in-person visits. In one report, of 335 prison patients evaluated via teledermatology, only 4.8% required an in-person follow-up for diagnostic purposes [35]. This study also went on to describe the functionality of teledermatology in the management of severe presentations of psoriasis and acne that necessitated systemic medication and regular laboratory monitoring. Studies conducted out of prisons in France and Korea similarly found that teledermatology was an effective tool in providing inmates greater access to specialty care [34, 36].

Direct to Consumer Teledermatology Platforms: Promise and Pitfalls

Direct to consumer (DTC) teledermatology platforms advertise readily accessible dermatologic care, that often bypasses the need for a pre-existing physician–patient relationship [37]. Although these services may provide some advantages, such as improved access, efficiency, and convenience, there is significant concern regarding conflict of interest, treatment by non-dermatologists, and the prescription of medication without a comprehensive history or adequate counseling [38, 39]. Although these deficiencies are countered by the assumption that DTC increases access to care, many popular DTC platforms are not well-suited to accommodate underserved populations.

A study by Gao et al. found that many highly popular DTC teledermatology platforms do not mitigate well-known barriers to access such as language, digital literacy, and insurance acceptance [37]. Of 14 popular DTC teledermatology websites evaluated in one study, only 4 provided the option of a non-English language interface; Spanish was only available on 2 platforms, and no Asian languages were offered on any application. Additionally, all sites required email registration, without an option for a simplified or alternative method of engagement. Given the aforementioned limitations in overcoming technological requirements among low-income populations, the necessity of email registration would likely continue to be a formidable barrier to increasing access via DTC teledermatology [10, 37].

Another study by Resneck et al. evaluated 62 simulated clinical encounters for 16 DTC telemedicine websites in 2016 [40]. Concerningly, they found that the care provided through these websites often lacked patient choice of clinician, transparency of clinician credentials, thoroughness, diagnostic and therapeutic quality, and care coordination.

A review of DTC pharmaceutical teledermatology platforms discusses additional issues including overdiagnosis, overtreatment, and wasted resources [41]. Another concern is that the existing model of DTC teledermatology redefines the physician–patient relationship by turning patients into consumers. In many of these applications, physician visits are set up to evaluate a patient's suitability for a prescription, not to determine the best treatment for a given problem. As such, patient interactions may be preferentially influenced by sales rather than optimal clinical care.

Emergency Implementation of Telemedicine During COVID-19 Surges in Low-Income Communities

Nearly 3 years since the arrival of SARS-CoV-2, the Omicron variant sent infections soaring throughout the globe. At the peak of the Omicron wave in NYC, Hispanic and Black demographics had the highest rates of cases and hospitalizations, respectively [41–43]. Hospitals in low-income zip codes were most severely affected due to overwhelming inpatient demand and staff illness [43, 44]. Encouragingly, many safety-net dermatology clinics in academic centers were able to quickly pivot to telemedicine to maintain continuity of care [45].

Optimization of Teledermatology in Vulnerable Populations

The implementation of teledermatology in vulnerable and low-income populations continues to be a challenge. As such, actionable strategies from clinics with experience treating these patients are helpful in increasing access and equity, as well as improving the quality of patient care. Table 4.3 outlines suggestions for optimizing patient engagement in telemedicine in a low-income population [3].

These strategies can be divided into three main categories: (1) Implementation of a triage system to determine which conditions are appropriate for teledermatology and which necessitate an in-person visit for diagnosis and/or management; (2) Assessment of patient-specific considerations (motivation, cultural and/or age-related biases, smart-device ownership, digital literacy); (3) Providing optionality and adjustments based on 1 and 2.

Table 4.3 Suggestions for increasing engagement in teledermatology for vulnerable populations

Suggestion	Helpful points
Implement a triage system	Most often, patients need a referral to be scheduled for a dermatology appointment. Triaging new patients based on the referral complaint allows conditions in need of procedures (e.g., cysts, warts, and keloids) to be preferentially scheduled in-person, whereas those more appropriate for teledermatology (e.g., acne, psoriasis, or eczema) to be managed virtually
Assess motivation	Patients' desire to participate in virtual care be highly variable even if their condition is fully amenable to teledermatology. Inquire about personal preferences to increase the likelihood of a successful encounter
Be alert for cultural and age-related biases	Patients may have preconceptions about virtual medicine as second-rate care, or they may feel they are relegated to telemedicine because of an overburdened clinic. It is important for patients to understand that it is their choice to participate in this type of visit
Evaluate for the presence of a smart device	Ownership of smart devices is not a given and can drop precipitously, especially in low-income elderly. It is best not to assume the patient has the tools to effectively engage in photo-sharing and/or video
Evaluate for technological competence	Ownership of a smartphone or prior patient portal activation does not guarantee digital literacy. It is worthwhile to inquire about the patient's ability to use the telemedicine platform prior to the visit [5]
Have a back-up system for video and photo exchange	Medicaid recipients, minority groups, and the elderly are known to have lower rates of patient portal activation and usage. Text message-based applications without cumbersome email and registration requirements are essential to salvage engagement [5]
Use reminders	Reminder calls and messaging with photo requests are useful in preparing patients for the appointment

(continued)

Table 4.3 (continued)

Suggestion	Helpful points
Experiment with workflow	Every community is different. Experiment with a variety of iterations of your telemedicine workflow to figure out what works best for your population
Pay special attention to the needs of non-native speakers	Assess the usability of the patient portal interface and/or text message-based telemedicine platform to accommodate non-English speakers. Use applications that allow for translator integration and have prompts in multiple languages
Provide optionality	Patients should feel that this is for their benefit and convenience, not the provider's. It is important to convey that they have a choice in the way in which they receive care

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Conclusion and Future Directions

The implementation of telemedicine in vulnerable populations can pose a significant challenge due to decreased rates of digital literacy, device ownership, and portal usage as well as inadequate administrative support. Nonetheless, patients in these communities are in the greatest need of additional avenues for access to healthcare. Children limited by school hours and caregiver commitments, essential and service industry employees unable to take off time from work, and palliative care and immunocompromised patients in need of enhanced precautions from infection would all benefit from a remote option in a flexible location. Using virtual medicine, individuals in rehabilitation facilities, prisons, nursing homes, rural communities, and countries without adequate dermatological services might be able to receive treatment heretofore unattainable. Notably, telemedicine continues to be indispensable as an emergency measure for the continuity of dermatological care during surges of COVID-19, especially in under-resourced settings.

Conflict of Interests None.

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5 Teledermatology: Effects on Patient Referral and No-Show

Catherina X. Pan, Rhea Malik, and Vinod E. Nambudiri

Introduction

Primary care physicians (PCPs) encounter a significant number of skin diseases, with 7–21% of all outpatient clinic visits estimated to be for skin complaints [1, 2]. When encountering skin conditions warranting specialist evaluation, PCPs, and other physicians often refer patients to dermatology for management. Traditionally, patients are directly referred to dermatologists for in-person evaluations. While in-person assessments allow for comprehensive skin exams and better visualization, they also present challenges regarding accessibility, cost, and wait times [3] (Table 5.1). These are important considerations as some skin conditions require expedited evaluations, such as when malignant lesions are suspected. Moreover, for patients from socioeconomically disadvantaged backgrounds and those living in rural areas, frequent in-person visits may be impractical given the lack of means of transportation, time, and financial barriers [4, 5] (Table 5.1).

A solution that has gained increased traction over the past two decades is teledermatology, whereby dermatology services are provided over electronic platforms as previously discussed in other chapters. Teledermatology care delivery can occur either asynchronously (store-and-forward) or synchronously (live visits with providers through telephone or video) [6]; either model could take place between referring providers and dermatologists or directly between patients and dermatologists [7]. Additionally,

Table 5.1 Challenges of in-person dermatology clinic visits [25, 28, 49, 50]

Patient concerns: • Lack of childcare or eldercare • Inability to take time off from work • Language or cultural barriers • Fear and anxiety about the appointment/ healthcare settings • Lack of clarity/ understanding of the reason for the appointment	*Accessibility:* • Lack of transportation • Lack of nearby healthcare providers- requiring patients to travel greater distances • Lack of knowledge about appropriate healthcare sites • Extreme weather/ traffic conditions • Physical or mental disability
Financial barriers: • Inhibitory cost for out-of-pocket expenses, such as co-pays • Inability to afford costs related to travel	*System capacity:* • High lead time for appointments • Reduced in-person staffing during COVID-19 pandemic • Limited time slot availability (e.g., solely during the workday)

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there are also hybrid models where care delivery combines elements of synchronous and asynchronous teledermatology [8]. This chapter discusses the impact of teledermatology on referrals and no-shows, both of which are key metrics in evaluating efficiency of healthcare resource utilization and allocation.

Impact of Teledermatology on Patient Referrals

Dermatology referral rates vary significantly by geographic region and from provider to provider. In the United Kingdom (UK), PCP referral to outpatient dermatology was observed to have increased 36% between 1994 and 2009—2.4 times greater than initially projected [9]. Given the limited numbers of dermatologists and healthcare resources, efforts have been made to examine whether referrals made are "necessary" or "appropriate." Studies in the UK and the Netherlands have found that 21–23% of patients did not need specialized diagnostic care or treatment and could have been appropriately managed by PCPs [7, 10]. Another small study (n = 54) of hospital-based practice in the UK found that nearly 60% of referrals were considered inappropriate by dermatologists [11]. The most common diagnoses considered to be referred inappropriately included viral warts, actinic/seborrheic keratoses, nevi, eczema, and acne [11]. Though provider education with referral guidelines has been shown to be effective in increasing the proportion of appropriate referrals up to 80%, the effects were not long-lasting, indicating the importance of continued provider education [11].

Teledermatology has been shown to reduce the number of referrals to dermatology and be an effective means to provide continued education to PCPs through constant provider feedback. In the following sections, we discuss the effect of telemedicine—both synchronous and asynchronous platforms—on patient referrals within dermatology.

Synchronous Teledermatology Referrals

Synchronous teledermatology visits allow patients to interact with dermatologists in real-time through media such as phone and video. Compared to in-person visits, synchronous teledermatology allows for savings in transportation costs and decreased wait times, eliminating some of the core barriers to healthcare access [12]. The concordance rate of diagnostic accuracy between synchronous visits and in-person clinic visits was generally high (87%) [13].

A randomized controlled trial of 204 patients conducted by Wootton et al. found that synchronous teledermatology reduced the number of dermatology referrals made by PCPs by 10–25% while maintaining comparable accuracy and patient satisfaction [12, 14]. The reduction was attributed to increased knowledge and experience with managing dermatological conditions among PCPs, who were present jointly during the televisit [14]. Practitioners studied estimated that being present at teledermatology consults provided an educational experience equivalent to ~6 days of dermatology training; though a qualitative estimate, this finding reflects the value of learning from specialist feedback through joint patient visits.

Moreover, synchronous televisits can improve triage for emergent dermatological conditions. In a study of patients with acute burns in the US, telemedicine triage of burn severity reduced percentage of patients requiring emergency air transport by 55.7% [15]. High levels of patient satisfaction and concordance rates between physicians evaluating burn size in-person and via telemedicine were observed, suggesting that patients were able to obtain appropriate care along with improved resource allocation [15].

Teledermatology has also been shown to decrease time to referral completion and definitive treatment. A chart review study of patients treated for skin cancers at a Veterans Affairs Medical Center found that teledermatology referrals were completed faster with shorter time to initial consultation, biopsy, and surgery than conventional referrals—4 versus 48 days ($p < 0.0001$), 38 versus 57 days ($p = 0.034$), and 104 versus 125 days ($p = 0.006$), respectively [3]. This finding highlights that televisits may help in triage of patients with different skin diseases, thereby prioritizing treatment of patients who require more urgent interventions, such as those with a high possibility of cutaneous malignancies and be a powerful tool in enhancing patient access.

Asynchronous Teledermatology Referrals

Asynchronous consultations are defined as clinical care delivery without continuous real-time interaction between patient and provider or between providers. One of the most common forms of asynchronous consultations is eConsults. eConsults involve direct communication, often between PCPs and specialists, over a secure shared electronic platform or electronic health record (EHR). Patient data, such as clinical images, and the corresponding question is stored and forwarded to the specialist to be evaluated, a model also known as store-and-forward teledermatology.

Asynchronous teledermatology has been shown to provide outcomes comparable to that of conventional, in-person clinic-based care and decrease time from referral to definitive intervention [16, 17]. Moreover, similar to its synchronous counterpart, it can act as an efficient mode of triage, determining which patients need to be evaluated in-person versus being managed through televisits [7]. Studies have shown that eConsults resulted in fewer in-person specialty visits, and those visits that did happen in person were cases requiring greater intervention [18]. For instance, in an analysis of biopsy rates for patients referred via teledermatology versus those referred by PCPs, the biopsy rates were 26.4% among the former group and only 10.9% among the latter, demonstrating a greater likelihood of requiring intervention [18].

Moreover, a multicenter cluster randomized controlled trial found that patient satisfaction tended to be similar between in-person and teledermatology visits, and that teledermatology consults reduced in-person referrals by 20.7% [19]. Turnaround times for eConsults were estimated to be 0.5 days in another cross-sectional study, with a median in-person follow-up time of 11 days when indicated [20]. In contrast, the conventional median wait time for in-person visit referrals was 26 days [20]. Additionally, mean time to definitive treatment was significantly reduced for patients referred through teledermatology compared to conventional referrals (80.7 versus 116.9 days; $p = 0.004$) [20].

The effects of patient-assisted, store-and-forward teledermatology systems on referral rates were also assessed in an international context [7]. In the Netherlands, all patients with dermatology eConsult referrals were evaluated in 2 days, compared to an average of 6 weeks for in-person evaluation. It was also found that 23% of patients were determined to not need hospitalization through televisits, highlighting that televisits' potential to save time and healthcare costs is broadly applicable [7].

Teledermatology also has the potential to increase healthcare access among racial minority and socioeconomically disadvantaged patients. Patients with eConsult referrals were significantly more likely to be non-white and be on Medicaid compared to conventionally referred patients [20]. Similar trends have been observed across specialties, highlighting telemedicine as an opportunity to reduce health disparities [21].

No-Shows in Dermatology

In clinical care, no-shows occur when a patient does not attend a scheduled appointment. No-show rates serve as a key metric of healthcare efficiency and present a number of costs to both patients and providers. Firstly, delay in diagnosis or treatment of skin conditions due to missed appointments may lead to progression of disease or complications. Secondly, no-shows decrease the efficiency of healthcare resource allocation through unnecessary utilization of provider capacity, support staffing, clinic space and equipment, which could be used for the care of other patients

[22]. From a health systems standpoint, no-shows significantly diminish hospital revenue. A recent study estimated that 67,000 no-shows outpatient clinic visits costed the healthcare system approximately seven million, for a loss per no-show of approximately $105 [23].

Historically, no-show rates are higher in medically underserved communities [24]. Clinic non-attendance is highly correlated with insurance status, with uninsured patients and Medicaid recipients most likely to miss their appointments [24]. Among pediatric dermatology patients, nonattendance rate was 37% among Medicaid-insured patients and 18% among privately insured patients [25]. Major driving factors may relate to the inability to take off time from work, lack of child and/or elder care, and inadequate transportation options [26]. Given the strong correlation between no-show rates and socioeconomic disadvantage and minority racial/ethnic status, some studies have asserted that no-shows can be considered a measure of health disparity [27].

Impact of Teledermatology on Patient No-Show

Synchronous Teledermatology

Overall, teledermatology is associated with lower no-show rates compared to in-person appointments. A retrospective review of 2253 patient visits in a Federally Qualified health center in New York compared no-show rates for dermatology visits conducted virtually and in-person over two 7-month periods between 2019 and 2021. Compared with solely in-person encounters, a program consisting of both in-person and televisit appointments was associated with a nearly 40% reduction in no-show rates (39–24%) and a resultant increase in total completed visits [28].

Similar findings were observed in pediatric dermatology settings. A study of pediatric dermatology clinics in the greater New York area with >90% of patients on Medicaid found that no-show rate decreased from 46% to 35% with the implementation of combination in-person and televisit programs [29]. Additionally, a pediatric Asthma Mobile Clinic focused on low-income communities in Chicago found that no-show rates decreased from 36% to 7.9% with the implementation of televisits, or an 18% reduction per month over the 10-month implementation period [30].

This trend was also observed in primary care clinics and other specialties. A prospective study examining both primary and specialty care clinics found that the no-show rate for telehealth visits during the COVID-19 pandemic was 7.5% ($n = 14$), significantly lower than both the no-show rate of 36.1% for in-office visits during the pandemic ($n = 56$) ($p < 0.0001$) and the pre-pandemic in-office no-show rate of 29.8% ($n = 129$) ($p < 0.0001$). Notably, patients were highly satisfied with televisits because of the convenience of appointment times and perception that the physician listened to concerns, explained lab results, and communicated a plan of action well [31].

The timeline of these studies aligns closely with the rise of the COVID-19 pandemic, which began in December 2019; this is likely due to a multitude of reasons. During this time, there was an immense effort in expansion of teledermatology capacity given the concern for iatrogenic COVID-19 disease transmission. The importance of access to specialty care was heightened given the concern of exacerbating preventable morbidity and mortality. Moreover, multiple policy measures were put in place to increase telemedicine accessibility, such as allowing interstate telehealth delivery, prescription of controlled substances via telehealth, and expanded funding and reimbursement of telehealth visits [32].

Given teledermatology mitigates some key barriers to healthcare access, it is also an opportunity for addressing disparities. In a study of 6883 patients in Massachusetts, researchers found that compared to in-person clinic visits, televisits had significantly lower no-show rates, with the greatest reductions seen for Black or African American, Latin Americans, and primary non-English-speaking patients [23]. This observation supports the hypothesis that televisits may help mitigate barriers to care and improve access to care, particularly for minority and/or underinsured patients.

Asynchronous Teledermatology

Overall, asynchronous teledermatology, or eConsults, reduces no-show rates and time to biopsy and surgical excision. A study by Wang et al. found that ambulatory referral patients had significantly lower no-show rates (4.8%, $n = 3$) and cancellation rates (12.9%, $n = 8$) to their scheduled appointment when converted to eConsults compared with conventional referrals (no-shows: 9.7% [$n = 246$]; cancellations: 29.4% [$n = 742$]; $p = 0.003$) [20].

Benefits of eConsults are particularly notable for those with barriers to specialty care access due to lack of insurance coverage or residence in rural settings [20]. A retrospective cohort study in Connecticut demonstrated that teledermatology visits reduced the no-show rate among Medicaid-insured patients from 84% to 24% by providing timely face-to-face follow-up after initial virtual consult [33]. Similar findings were observed in pediatric dermatology populations where eConsults significantly improved access among underserved populations [34].

eConsults served as a particularly valuable tool during the COVID-19 pandemic. In a quaternary hospital in Massachusetts, eConsults volume increased by 5% daily at the beginning of the pandemic [35]. eConsults and asynchronous eVisits (a direct-care asynchronous questionnaire-based encounter via a web portal) came to represent roughly 20% of all consult volume during April 2020 [36]. Given their high rates of completion, increased rates of minority and Medicaid patients served, and efficient patient triage, asynchronous teledermatology serves an important role in dermatology care delivery.

Limitations

While teledermatology has strong potential for addressing a number of disparities in healthcare delivery and optimizing resource allocation for patient care, it also faces a number of challenges. A systematic review of teledermatology studies by Warshaw et al. between 1990 and 2009 found that the diagnostic concordance rate between in-clinic and asynchronous visits was 65%, with an increase to 87% for synchronous visits [13]. While improvements in technology will likely increase diagnostic accuracy over time, effective teledermatology referrals require proper training and infrastructure to be in place. Key factors associated with success included: 1) appropriate patient triage, 2) quality clinical photographs, and 3) quality dermatoscopy photographs when cutaneous malignancy is suspected [5]. Referring providers should have prior training in dermatology or have a system in place to allow for a provider with dermatology training to provide patient triage. Training guidelines for teleimagers—individuals who take clinical photos—are important for standardized, quality clinical photos. Quality digital equipment such as cameras and dermatoscopes are necessary for high-resolution clinical photographs, especially of lesions suspicious of malignancy. An additional consideration is a need for encrypted data transfer software, which is essential to protect patient privacy in transmission of clinical pictures [37]. In a study of a store-and-forward dermatology system, wherein researchers had patients evaluated by multiple dermatologist providers and compared the inter-observer reliability between virtual and in-person visits, concordant diagnoses were significantly more likely when image quality was considered good (77% vs 23% of images considered poor in quality) [7, 38].

Secondly, a practical limitation of teledermatology is that other suspicious lesions may be missed when only isolated images are sent to dermatologists in lieu of in-person visits, which allows for full-body skin exams [39]. A study of over 400 patients at a Veterans Affairs hospital found that there was a slightly higher rate of melanoma diagnosis among incidental lesions (9.8%) identified by dermatologists on referred patients than biopsied index lesions (5.7%), for which the patient was initially referred. This finding highlights the continued importance of comprehensive, in-person skin exams for patients at higher risk of cutaneous malignancies given possibility of disease not identified by the referring physician.

Limitations of Synchronous Teledermatology

Synchronous teledermatology faces a unique set of challenges. Specifically, technological demands associated with televisits may further exacerbate disparities in dermatological care if not properly addressed. Despite overall improving racial disparities in care access, synchronous video teledermatology were less frequently used by individuals who were older, female, Black, Latin American, and had lower household income [40]. Asian race, non-English language as the patient's preferred language, and Medicaid enrollment status were also independently associated with fewer completed telemedicine visits [40].

This disparity is likely driven by a technological divide, given limited digital equipment access and/or literacy disproportionately affects socioeconomically, medically disadvantaged, and older patient populations. More than a third of US households headed by a person aged 65 years or older do not have access to a computer, and more than half do not have a smartphone [41]. Children in low-income households were also substantially less likely to have access to a computer, as were Black or Hispanic children [42]. Patients in communities with a higher Social Vulnerability Index (SVI), as defined by the Center for Disease Control, were significantly more likely to face the following barriers to televisits: language barrier, low use of/access to the patient portal, lack of reliable Internet or appropriate device, lack of comfort with technology, and discomfort being forthright over phone/video [43].

Limitations of Asynchronous Teledermatology

Despite its strengths, eConsults similarly face challenges. While popular among patients, eConsults can increase workload and necessitate workflow change, resulting in lack of reimbursement for specialists and raising privacy concerns and technical challenges [44–46]. At a systems level, eConsults can pose challenges due to different licensure requirements across state lines, ongoing infrastructural resource requirements, and lack of EHR integration [44–46].

Additionally, while eConsults converted to in-person visits may result in lower no-show rates, there may be confounding factors, such as the severity of skin condition diagnosed. Visits converted to an in-person consultation following eConsult may require more urgent care, which may account for some of the difference in no-show rates compared to patients seen via standard referral. Further investigation in the impact of asynchronous teledermatology on patient no-shows is warranted.

Hybrid Teledermatology

Some outpatient institutions have implemented "hybrid" teledermatology models—incorporating elements of both synchronous and asynchronous technologies. These models allow for a blending of some of the best features of synchronous and asynchronous teledermatology—including the interactive nature of synchronous care with high-resolution images and the availability of clinical data from asynchronous care [8]. However, referral and no-show rates are difficult to tabulate for these hybrid models given the overlap in care methods and related variables [47]. Most existing literature assess asynchronous and synchronous models separately; hence, future work to evaluate the effects of hybrid dermatology models on no-show and referrals are warranted.

Future Directions

Teledermatology presents significant promise in reducing unnecessary referrals and no-shows. Not only is patient satisfaction with teledermatology high, surveyed-PCPs reported enhanced knowledge through direct communication with specialists and improved clinical confidence, illustrating teledermatology's additional capacity as a tool for clinician education [13, 48].

Numerous strategies have been proposed to address barriers within teledermatology and improve patient access (Table 5.2). These fall within

Table 5.2 Strategies to improve care delivery through teledermatology platforms [28, 46, 51]

Patient-centered improvements	• **Elicit patient preferences** to participate in virtual care or in-person visits when referrals are made to dermatology services • **Consider cultural contexts**. Patients may have a varying perception of teledermatology based on their cultural backgrounds and experiences. Therefore, eliciting patient understanding of and providing reassurance around the quality of care of teledermatological services are important • **Evaluate possible language and/or disability barriers**. Assess the usability of the telemedicine platform to accommodate non-English speakers as well as individuals who may be hard of hearing, seeing, or speaking
Technology access	• **Determine extent of digital access**. Inquire about the presence of smart device/broadband access at the site where the patient may engage in the clinical encounter • **Assess technology literacy** by inquiring about familiarity with technology and ability to use telemedicine platforms • **Create multiple streams for digital exchange**. Text message-based applications and those not involving email and registration requirements demonstrate a high rate of patient engagement • **Provide patient resources** to aid patients in navigating digital platforms including digital and printed instructions • **Ensure patient privacy** by partnering with digital platforms that are secure and HIPPA compliant
System capacity	• **Implement triage system**. Patients in need of procedures can be preferentially scheduled in-person while visits most appropriate for teledermatology can be managed virtually to reduce appointment lead time • **Provide reminders**. Calls and reminder messages may prepare patients for their appointments • **Allot appropriate time** based on patients' familiarity with technology, language needs, and others requirements. Some patients may require more time per visit to adapt to televisits

one of three categories: patient-centered improvements, technology access, and system capacity (Table 5.2). While these strategies may hold promise in improving telemedicine care delivery, additional research is needed to assess their overall efficacy and cost-effectiveness within dermatology.

Conclusion

Referral and no-show rates are key indicators of accessibility and efficiency in healthcare. Finding ways to reduce unnecessary referrals and no-shows is critical for appropriate usage of healthcare resources and provision of timely care to patients. Key challenges include geographic and socioeconomic barriers, which disproportionately affect minority and rural populations. Teledermatology presents immense potential as a solution to these challenges. Studies have shown that teledermatology systems, whether asynchronous or synchronous, provide quality, timely care and can reduce health disparities. Patients are highly satisfied with their care with lower no-show rates given the ease of attending visits virtually. Furthermore, diagnostic accuracies are often concordant with in-person visits when proper teleimaging techniques and equipment are implemented. In facilitating interactions between referring providers and specialists, teledermatology also enables continued learning for PCPs, reducing the number of unnecessary referrals in the long term. Future investigations into the optimal modality of employing teledermatology services in conjunction with in-person visits are necessary.

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Conflict of Interest None declared.

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6 Teledermatology: Economics and Cost-Effectiveness

Adam Zakaria and Erin H. Amerson

Introduction

Dermatology is a natural fit for telemedicine applications given its visual nature. However, despite several decades of use across countries and healthcare systems, there remains a lack of consensus regarding the economic effects of teledermatology. In this chapter, we will outline the current landscape of knowledge regarding teledermatology's cost and cost-effectiveness.

Healthcare Cost-Effectiveness Definitions

Overall, most studies examining cost-effectiveness use methods comparing two or more healthcare options and determine which provides the most benefit for the least relative cost. A major barrier to generalizability of any cost-effectiveness study is the wide variability in structures and payment models for teledermatology, as each analysis will be limited to an individual system's unique characteristics. Additionally, assessing cost-effectiveness requires defining who is burdening the cost and who is receiving the benefit.

In order to discuss the cost-effectiveness of teledermatology, we will first review and define some general terms and cost components used to measure cost-effectiveness within healthcare, while also examining differing beneficiary perspectives.

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Payor Structure

Insurance

Payment for most healthcare delivered in the United States is mediated through health insurance, and cost analyses may take the perspective of cost to the insurer or cost to the insured. In the United States, the fee-for-service insurance model is the most common [1], whereby the insurer pays the provider or health system for each service rendered. In other insurance models, such as capitated systems and value-based care systems, the system may receive a flat payment for each patient enrolled. Regarding costs to the insured under a health insurance model, the insured pay premiums, often subsidized by their employer or federal and/or state governments. When individuals access medical care, payments are mediated through the insurer and the amount paid by the individual depends upon the structure

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of the health insurance plan [2]. Many insurance plans have deductibles or require the insured to pay a percentage of medical costs. Cost to the insured for any service, including telemedicine, varies widely depending on the plan structure and the contract negotiated by each insurer with the provider or healthcare system.

Service Contract

A service contract describes a payment arrangement where the dermatology provider has a contract to bill the healthcare system on a per-case basis independent of medical insurance. An example of this would be a primary care clinic paying a dermatologist a fixed amount per teledermatology case reviewed [2].

Out-of-Pocket

With out-of-pocket payments, patients or their employers pay directly for the services they receive without mediation through insurance reimbursements. Some examples of out-of-pocket healthcare spending include concierge medicine, direct private care, and certain medical services not covered by insurance, such as elective cosmetic procedures. In recent years, online direct-to-consumer healthcare delivery platforms have emerged, including primary care, mental healthcare, pharmaceutical services, and other forms of in-person care or telehealth where patients pay the provider directly without an insurance intermediary. Teledermatology is no exception, with many private direct-to-consumer companies adopting a direct payment model [2].

Beneficiary Perspective

Healthcare System Cost-Effectiveness

The typical beneficiary perspective pursued for cost-effectiveness analyses among healthcare interventions is that of the healthcare system. From this perspective, the objective is to select the strategy of healthcare delivery that produces the least cost for the healthcare system without negatively impacting the quality of healthcare delivered [3]. Effective strategies from this perspective lead to increased efficiency of healthcare delivery. Increased efficiency can come in the form of either increased quality of healthcare delivery or decreased costs [4]. Ways to increase the quality of healthcare delivery include implementing interventions that lead to more accurate diagnosis and management of medical problems and facilitate improved adherence among patients. Strategies that decrease costs include those that decrease overhead costs associated with healthcare delivery (e.g., clinic space, equipment, personnel) or decrease the total amount of healthcare that needs to be delivered.

Patient/Societal Cost-Effectiveness

An increasingly popular perspective among cost-effectiveness analyses is from that of society or the individual patient. From this perspective, delivering higher quality, more efficient care at a lower cost is still favored. However, rather than solely focusing on the health benefits obtained at a set cost to the healthcare system, this perspective also incorporates other societal or individual costs tangential to healthcare [3]. For example, these types of cost-effectiveness analyses also incorporate costs associated with attending medical appointments, including the costs of missing work, arranging childcare, and traveling to the medical office. Pursuing cost-effectiveness analyses from the perspective of society at large is increasingly favored as a more holistic approach to evaluating healthcare interventions and strategies [4].

Cost Implications of the Two Major Models of Teledermatology: Store-and-Forward vs. Live Interactive

Teledermatology systems and payment models can be organized into many different structures, each with unique effects on economics. We will outline some factors contributing to costs and savings, highlighting the two primary teledermatology models that have been economically evaluated in the published literature.

Store-and-Forward Teledermatology

In store-and-forward teledermatology (SAFT), photos of a dermatologic problem are sent to a dermatologist for asynchronous review. There are multiple models of SAFT. SAFT may be initiated by a patient who desires a consultation from a dermatology provider, or from a non-dermatology provider who seeks advice on virtual comanagement or triaging of dermatologic problems for their patients [5].

Direct-to-Consumer

In this form of SAFT, patients can upload photos to a for-profit web platform or application staffed by providers who are independent contractors and generally not part of the patient's healthcare network or system. Many of these platforms limit the diagnoses they provide consultation for, and most only accept direct payment, although a handful accepts insurance [6, 7]. Some studies have questioned the quality of care provided through these platforms [8, 9].

Patient-to-Provider

During the COVID-19 pandemic, regulatory burdens on telemedicine (HIPAA waivers, telemedicine practice across state lines) were relaxed and many insurances began offering fee-for-service reimbursement for SAFT [10]. As such, patients and providers are increasingly taking advantage of the option to allow patients to upload photos to their electronic health record platform and request a virtual consultation from their existing dermatology provider. Under some circumstances, the provider may bill the insurer for this service. One recent study found that patient-submitted photographs are not consistently of sufficient quality to facilitate teledermatology review [11]. Furthermore, the economic implications of this model have not yet been evaluated as of this publication.

Provider-to-Provider

Healthcare systems with capitated payment models tasked with providing medical care to large patient cohorts for flat payments have economically benefited by using SAFT as a triaging mechanism [12, 13]. In this model, the dermatologist determines whether the patient needs to be seen in-person by a dermatologist or whether the primary care physician can manage the patient's dermatologic problem with treatment recommendations from the dermatology provider. There is no universal triaging framework for teledermatology, but the determination is typically made based on some combination of diagnosis, disease severity, patient distance from the nearest dermatology office, and need for a dermatology-based procedure, among other considerations.

Cost-Effectiveness of Store-and-Forward Teledermatology

Based on the current literature, it seems that provider-to-provider SAFT leads to cost savings compared to standard in-person referral systems in most cases, although it was cost neutral in a minority of cases (Table 6.1) [12–28]. Below, we describe the unique cost components and benefits of SAFT from a cost-effectiveness perspective.

Costs Associated with Store-and-Forward Teledermatology

Hardware and Software

Costs associated with hardware and software necessary to facilitate SAFT are unique additional costs that are less applicable to standard in-person visits [13, 14, 22, 23, 25, 27]. SAFT referral systems may be built into existing electronic medical records or require a separate soft-

Table 6.1 Cost-effectiveness analyses of store-and-forward teledermatology systems

Primary author [citation]	Year	Country	Patient/societal costs included	Cost implications
Datta [13]	2015	The United States	Yes	Cost-effective
Eminović [14]	2010	The Netherlands	Yes	Cost neutral
Ferrándiz [15]	2008	Spain	Yes	Cost-effective
Lim [16]	2012	New Zealand	No	Cost-effective
Livingstone [17]	2015	The United Kingdom	No	Cost-effective
Lopez-Villegas [18]	2020	Spain	Yes	Cost-effective
Moreno-Ramirez [19]	2009	Spain	Yes	Cost-effective
Morton [20]	2011	The United Kingdom	No	Cost-effective
Os-Medendorp [21]	2012	The Netherlands	Yes	Cost-effective
Pak [22]	2009	The United States	Yes	Cost-effective
Parsi [23]	2012	The United States	Yes	Cost-effective
van der Heijden [24]	2011	The Netherlands	No	Cost-effective
Vidal-Alaball [25]	2018	Spain	Yes	Cost-effective
Whited [26]	2003	The United States	Yes	Cost neutral
Yang [27]	2018	The United States	No	Cost-effective
Zakaria [12]	2021	The United States	No	Cost-effective
Zarca [28]	2018	France	No	Cost-effective

ware application. In addition to software costs, other technological costs associated with SAFT include devices (e.g., cameras, computers) and ongoing software and IT support. These costs are primarily front-loaded, meaning that the establishment of a SAFT system often requires an upfront financial commitment [12].

With the widespread adoption of electronic health record systems at most major institutions, some systems have built-in applications that allow providers to use their own devices or smartphones to securely upload photos directly into a patient's chart, and to link that photo to an electronic consultation [29]. Practitioners and healthcare systems encouraging this practice may lead to reductions in some of the aforementioned hardware and software costs.

Personnel, Training, and Overhead

Other costs associated with implementation of a SAFT system include training costs for both referring and reviewing providers, cost for clinic space to review the referrals, and compensation for reviewing dermatologists. Costs also depend on the context under which the referring and reviewing providers operate (i.e., from home versus from the medical office, using their own device/equipment versus those belonging to a medical practice). As with hardware and software, some of the costs associated with personnel and training will be front-loaded and therefore relative additional costs should decrease with increased patient volume over time [12].

Cost Savings Associated with Store-and-Forward Teledermatology

The cost savings associated with SAFT are derived primarily via the reduction in the number of live, in-person healthcare visits to facilitate decreased societal costs for patients and decreased healthcare costs for the medical system [12].

Patient/Societal Perspective

From the patient perspective, those who submit a teledermatology referral and can be managed without an in-person dermatology appointment avoid incurring the costs associated with attending in-person clinic visits, such as unpaid work leave, childcare, and transportation. Additionally, studies have found that SAFT has the potential to shorten wait times for accessing dermatologic care compared to traditional in-person referral options [29, 30]. Expedited care likely benefits patients, who experience a quicker time to diagnosis and appropriate management, and hypothetically leads to fewer outpatient, urgent and emergent medical visits attributed to disease progression. Additionally, quicker time to diagnosis likely also reduces patient discomfort, frustration, and possibly missed work while patients are waiting to be evaluated by a dermatologist [18, 19, 23, 26]. However, more data are needed to confirm these hypotheses.

Healthcare System Perspective

The economic implications of SAFT from the medical system perspective depend upon the payment model being used. For closed or capitated medical systems, such as those that exist in the United Kingdom and Sweden [31, 32], certain US systems (e.g., Veterans Affairs system, some county hospitals), or integrated managed-care delivery systems (i.e., Kaiser Permanente), the healthcare system or provider is paid a fixed amount regardless of the amount of medical care delivered. Therefore, the incentive for these systems is to provide efficient care and limit the need for unnecessary visits [12, 13, 26, 27]. Closed systems also save on costs by steering patients towards comparatively less expensive primary care visits instead of dermatology visits. These incentives align well with the goals of SAFT, and therefore multiple healthcare systems have been shown to benefit from the cost savings associated with SAFT triage (Table 6.1). Conversely, in fee-for-service payment models, such as those that exist in most systems in the United States and Japan, the medical system is reimbursed for the number of services or procedures they provide [1, 2]. Therefore, the incentive for these systems is to provide a higher amount of healthcare, with a greater focus on generating revenue rather than limiting costs. From the perspective of the United States, SAFT services generally have poor reimbursement rates, and prior to the COVID-19 pandemic, were only approved for select circumstances, such as for rural patients who had established care with a dermatologist but lived far away from their office [10]. The COVID-19 pandemic has led to legislative changes that have improved reimbursement rates and eased restrictions in providing SAFT services, but SAFT still remains underutilized in fee-for-service healthcare systems given the hurdles to revenue generation [10]. Please see Chap. 9 on Regulations and Reimbursement for more information on this topic.

Live Interactive Teledermatology

In live interactive teledermatology, patients engage directly with a dermatologist via videoconferencing in real-time. Before the COVID-19 pandemic, this form of teledermatology was primarily used to provide care to patients living in rural or remote areas who would otherwise need to travel a great distance to be seen by a dermatologist. During the COVID-19 pandemic, it was widely adopted across many systems and specialties to limit in-person interactions [10]. While studies have been mixed regarding patient and provider preferences for live teledermatology compared to in-person visits [33–35], many institutions have continued to practice live teledermatology given its inherent convenience. In contrast to the triaging goal of SAFT, live interactive teledermatology functions similarly to an in-person clinic visit in which evaluation, diagnosis, and management plan are performed in real-time and transmitted immediately to the patient through direct provider-patient communication. Live interactive visits have primarily been described within traditional fee-for-service or capitated insurance models (Table 6.2). Direct-to-consumer models for live interactive teledermatology visits have not been documented in the current literature, though such arrangements probably exist in practice given the growing popularity of concierge or direct private healthcare models.

Cost-Effectiveness of Live Interactive Teledermatology

Studies regarding the cost-effectiveness of live teledermatology systems have yielded mixed results, with live interactive teledermatology producing cost savings in some systems and increased costs in others (Table 6.2) [36–44]. Importantly, the most recent study to evaluate cost-effectiveness of live interactive teledermatology is from 2007 as per our literature review

Table 6.2 Cost-Effectiveness analyses of live interactive teledermatology systems

Primary author [citation]	Year	Country	Patient/societal costs included	Cost implications
Armstrong [36]	2007	The United States	No	Cost-effective
Bergmo [37]	2000	Norway	Yes	Cost-effective
Burgiss [38]	1997	The United States	No	Cost-effective
Loane [39]	2001	New Zealand	Yes	Cost-effective
Loane [40]	2001	New Zealand	No	More costly
Oakley [41]	2000	The United Kingdom, New Zealand	Yes	Cost-effective
Persaud [42]	2005	Canada	Yes	More costly
Seghers [43]	2006	Singapore	Yes	Cost-effective
Wootton [44]	2000	The United Kingdom	Yes	More costly

[36]. Therefore, any analysis is based on literature from 15 to 25 years ago. Given the advent of modern web-based videoconferencing technology and the ability to use personal smartphones and other devices to access videoconferencing platforms, we can hypothesize that more current analyses might yield different results. Nonetheless, similar to SAFT, the overall cost-effectiveness of live interactive teledermatology depends upon the circumstances under which the teledermatology is being performed and the balance between associated costs and savings.

Increased Costs Associated with Live Interactive Teledermatology

Hardware and Software

Implementation of a live interactive teledermatology system is associated with several costs. First, live interactive teledermatology requires both the dermatologist and the patient to have the appropriate technological capabilities to participate in a videoconferencing call [40, 43]. These include video cameras, audio set-ups (e.g., microphone, headset), and videoconferencing software that is compliant with patient privacy laws. In addition, ongoing software and IT support are often required. As with SAFT systems, these are primarily upfront costs, meaning that the per unit cost of operating live teledermatology will be highest at the outset and should decrease as more patients are served and dilute the initial set-up costs [40, 43].

Personnel, Training, and Overhead

Given that live teledermatology is operated in real-time like an in-person visit, the costs associated with providing in-person healthcare may still apply, depending on the provider's operating context. These include the cost of clinic space and compensation for dermatologists and other personnel providing and facilitating care [37–39]. Unlike SAFT, patients and providers often do not require special training to engage in live interactive teledermatology.

Cost Savings Associated with Live Interactive Teledermatology

In contrast to SAFT, which primarily produces cost savings by reducing the number of in-person healthcare visits, the cost savings associated with live interactive teledermatology are largely related to decreased societal costs for patients and potentially decreased operating costs for the medical system [36–39, 41, 43].

Patient/Societal Perspective

From the patient perspective, live teledermatology reduces the need for patients to attend an additional in-person visit to receive dermatologic care. Avoiding an in-person clinic visit provides cost savings to the patient given they are not harmed by the potential costs associated with coordinating an in-person visit (e.g., unpaid work leave, childcare, transportation) [39, 41, 44]. The effects of live teledermatology on wait times for patients seeking dermatologic care have not been analyzed in the literature, and therefore it is unknown whether it would provide cost savings associated with expedited care, such as decreased interim medical visits while waiting to be seen.

HealthCare System Perspective

The economic implications of live teledermatology from the medical system perspective depend upon many factors, including the balance of costs and revenue, as well as the payment model. As with SAFT, costs also depend on the context from which the provider operates (i.e., home or at the office). For closed or capitated medical systems that are paid a fixed amount per patient regardless of the amount of medical care utilized, the cost implications are unclear given cost-effectiveness is not clearly superior or inferior to standard delivery of in-person dermatology care. In fee-for-service payment models, where reimbursement is based upon the number of services or procedures provided, live teledermatology services have historically had better reimbursement rates and fewer insurance restrictions compared to SAFT, with improvements in both areas associated with increased demand and need for telemedicine in the setting of the COVID-19 pandemic [10]. Even with these favorable changes, reimbursement for live interactive teledermatology is generally worse than reimbursement for in-person dermatology visits, especially given the inability to perform office-based procedures [45]. Therefore, from an economic perspective most fee-for-service-based healthcare systems will favor standard in-person visits. Please see Chap. 9 on Regulations and Reimbursement for more information on this topic.

Future Considerations

Implementation of teledermatology systems accelerated in the setting of the COVID-19 pandemic because it provided a safe way for patients to access care without the risk of in-person exposure to healthcare settings. The acceleration was driven by patient and provider demand for virtual care but was also incentivized by government programs that relaxed restrictions regarding who could receive telemedicine services and increased reimbursement [10]. While much has changed in a brief period of time, the fast-moving nature of technology ensures that cost assessments of telemedicine will be forever changing. For instance, the integration of artificial intelligence applications is likely to have a profound impact on the future of telemedicine and its costs [46, 47]. Additionally, changes to future healthcare delivery models, such as the advancement of accountable care organizations, may also have consequences for costs and reimbursements. As we look into the future, it will be important to study the cost-effectiveness of teledermatology in the face of these changing contexts to determine whether they should be considered as permanent fixtures within healthcare.

Conclusion

Cost-effectiveness assessments of teledermatology depend upon the type of teledermatology implemented, the system within which it is implemented, and the beneficiary perspective. Given the countless permutations of different combinations of teledermatology delivery and healthcare payment systems, it is very difficult to provide a "one-size-fits-all" assessment of cost-efficiency. Overall, most studies suggest SAFT produces cost savings, primarily by triaging referrals to reduce the quantity of in-person dermatology visits and by reducing patient costs associated with in-person visit attendance. Live interactive teledermatology has produced mixed results regarding relative cost-effectiveness compared to live in-person visits. However, the available evidence may not represent current-day cost-effectiveness, especially given that live interactive teledermatology has generally been favored in practice given clear, consistent reimbursement practices. Teledermatology can be a cost-effective mechanism for delivering dermatologic care, but limited reimbursement continues to hinder its economic feasibility thereby limiting its implementation.

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7 Teledermatology: Implementation

Francine T. Castillo, Sara B. Peracca, and Dennis H. Oh

Introduction

For telehealth interventions to achieve optimal impact, they must ideally be efficiently and effectively implemented for target users and populations to be widely adopted and correctly used. No longer a novel innovation, teledermatology is now a relatively mature telehealth specialty with considerable experience and data that can be interpreted through the lens of implementation science to help inform future applications. Implementation science is a relatively new, multidisciplinary field of scientific inquiry which seeks to study methods that promote the translation of research and other evidence-based findings into routine practice [1].

The differing types of teledermatology—store-and-forward or asynchronous, live synchronous video, and hybrid models—have different infrastructure, technology, and workflow demands which may affect implementation [2]. Needs of different user groups, such as non-dermatologists and dermatologists, as well as patients, are also important considerations, as is the environment in which implementation occurs. For example, teledermatology is used in both the outpatient and inpatient settings, for consultation among clinicians as well as direct-to-patient care, and in organizational units ranging from individual private practices to large healthcare organizations.

The application of implementation science tools and methods can provide a systematic approach to both planning and evaluating teledermatology programs to optimize their impact [3, 4]. This chapter will briefly introduce some common implementation science frameworks that have been used to understand telehealth interventions in general, and then use one of these to examine the implementation of teledermatology, illustrated by examples from the published literature. We focus on facilitators and barriers broadly common to teledermatology implementation efforts, though where appropriate we highlight features that may be specific to a particular modality.

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Frameworks Used to Guide Implementation Efforts

A comprehensive discussion of all theories and frameworks is beyond the scope of this review, and not all have been applied to telemedicine (see Tabak 2012 for a review of 62 dissemination and implementation science theories and frameworks) [5]. The two most commonly used theories for evaluation of telemedicine include the Technology Acceptance Model and the Unified Theory of Acceptance and Use of Technology. Both aim to understand why technology adoption occurs and to provide insight to improve user acceptance but fail to include socio-cultural and organizational factors, and have had mixed results in predicting acceptance and use in healthcare [6, 7].

Additional theories used to identify factors influencing telehealth effectiveness include the Organizational Theory for Implementation Effectiveness (OTIE), the Normalization Process Theory, Health Behavior Theories, and Theories of Organizational Change [8–13]. These theories and others are then operationalized in varying degrees into frameworks to assist in planning, monitoring, and evaluating programs. For example, the Consolidated Framework for Implementation Research (CFIR) incorporates aspects of 19 theories. Reach-Effectiveness--Adoption-Implementation-Maintenance (RE-AIM) is another common framework developed to facilitate the public health impact of research and to encourage examination of each of the 5 RE-AIM dimensions [14]. In addition to CFIR and RE-AIM, frameworks that have been used for telemedicine programs include the Telehealth Service Implementation Model, Precede-Proceed, and Promoting Action on Research Implementation in Health Services [15–20]. Frameworks that have been utilized specifically for understanding teledermatology implementation include CFIR [21] and RE-AIM framework [8, 22]. In addition, the Organizational Readiness for Change (ORC) Survey instrument has provided a means to assess organizational factors impacting the early stages of teledermatology programs [3, 23–25].

We use CFIR to organize our discussion of barriers and facilitators in teledermatology implementation. CFIR is helpful in that its 5 domains are broadly defined, encompassing aspects of other frameworks and theories, and yet constructs within its domains provide detailed descriptions of factors to consider for effective implementation. For example, it identifies individual, organizational, and community factors that influence implementation and includes characteristics of the intervention and of the process itself to consider, recognizing that different developmental stages of a project require different considerations [26].

Methods

We screened the published literature from 2010 through July 10, 2022, by searching PubMed for "teledermatology" and "implementation." The search resulted in 96 publications of which 45 met the following criteria: 1) English language publication and 2) Content relevant to the implementation process, specifically including factors outlined by the CFIR framework. We included primary research studies and review articles. We also searched using "teledermatology" and "RE-AIM" which yielded one result [22] and "teledermatology" and ("CFIR" or "Consolidated Framework") which yielded no results, though 1 work arose after additional research, reflecting the relative novelty of these frameworks in the field of teledermatology. We read an additional 59 publications which were cited in the articles initially identified. More than half (59.6%) of the articles we examined discuss teledermatology in the United States. While not exhaustive, our findings provide a survey of important aspects of the current published work on teledermatology implementation.

Barriers and Facilitators of Teledermatology Implementation

Identifying barriers and facilitators is critical and allows the development of targeted strategies such as promoting adaptability and providing local technical assistance [27]. We organize teledermatology implementation barriers and facilitators by CFIR's five domains and the constructs or elements within each domain (Table 7.1 and Fig. 7.1).

Table 7.1 CFIR domains and constructs

<table>
<tr><th colspan="4">I. Intervention characteristics</th></tr>
<tr><td>Intervention Source</td><td colspan="3">• Internal (e.g., arising within a practice or organization)
• External (e.g., mandated by a governing body)</td></tr>
<tr><td>Evidence strength and quality</td><td colspan="3">• Scholarly studies (e.g., randomized clinical trials)
• Operational experience (e.g., quality improvement data)</td></tr>
<tr><td>Relative advantages and disadvantages</td><td colspan="3">• Pros (e.g., improved patient access)
• Cons (e.g., medicolegal exposure, technology challenges)</td></tr>
<tr><td>Adaptability</td><td colspan="3">• Ability to meet local needs (e.g., fit in with practical workflows)
• Ability to leverage local resources (e.g., usage of social networking platforms)</td></tr>
<tr><td>Trialability and piloting</td><td colspan="3">• Ability to start small and scale (e.g., with a limited number of users or practice settings)</td></tr>
<tr><td>Complexity</td><td colspan="3">• Number of steps for each user (e.g., clicks in an app)
• Number of steps for process (e.g., handoffs among users)
• Scale (e.g., number of sites)</td></tr>
<tr><td>Design quality and packaging</td><td colspan="3">• User experience (e.g., user interface in app)
• Presentation (e.g., marketing, rollout with auxiliary technology/services)</td></tr>
<tr><td>Cost</td><td colspan="3">• User (e.g., minimization of patient travel expenses, reduced fees)
• Healthcare organization (e.g., equipment, additional personnel, avoidance of delayed care)
• Society (e.g., worker productivity)</td></tr>
<tr><th colspan="2">II. Outer Setting</th><th colspan="2">III. Inner Setting</th></tr>
<tr><td>Patient needs and resources</td><td>• Needs (e.g., timeliness of care, desire for in-person care).
• Resources (e.g., ability to own or use technology)</td><td>Structural characteristics</td><td>• Architecture (e.g., departmental relationships, hierarchy).
• Resources (e.g., funding mechanisms, expectations)
• Size (e.g., single practice, multispecialty, regional, or national presence)</td></tr>
<tr><td>Group relationships</td><td>• Connections to outside groups (e.g., awareness of professional organization resources and outside funders)</td><td>Networks and communication</td><td>• Individuals (e.g., clinical champion and department head)
• Organizational units (e.g., primary care, dermatology, business office, information technology)</td></tr>
<tr><td>Peer influence</td><td>• Colleagues (e.g., talks by thought leaders)
• Professional organizations (e.g., endorsements by researchers or clinical leaders)</td><td>Culture</td><td>• Stable organizational characteristics (e.g., historical legacy, mission statement)</td></tr>
<tr><td>External policies and incentives</td><td>• Governmental rules and regulations (e.g., related to patient privacy and provider reimbursement)</td><td>Implementation climate</td><td>• Capacity and receptivity to change (e.g., enterprise-wide initiatives for telehealth)</td></tr>
</table>

(continued)

Table 7.1 (continued)

IV. Characteristics of individuals	
Knowledge and beliefs	• Knowledge (e.g., facts driving an intervention, practical know-how on using teledermatology) • Beliefs (e.g., clinicians' valuation of teledermatology)
Self-efficacy	• Confidence in one's ability to change (e.g., providers envision how to incorporate teledermatology into their daily workflow)
Individual stage of change	• Skill (e.g., provider becomes more proficient in using teledermatology with time) • Attitude (e.g., provider becomes more enthusiastic after seeing impacts of teledermatology)
Identification with organization	• Perceptions (e.g., users' feelings about mission aligned with their own beliefs) • Commitment (e.g., willingness to put in extra effort)

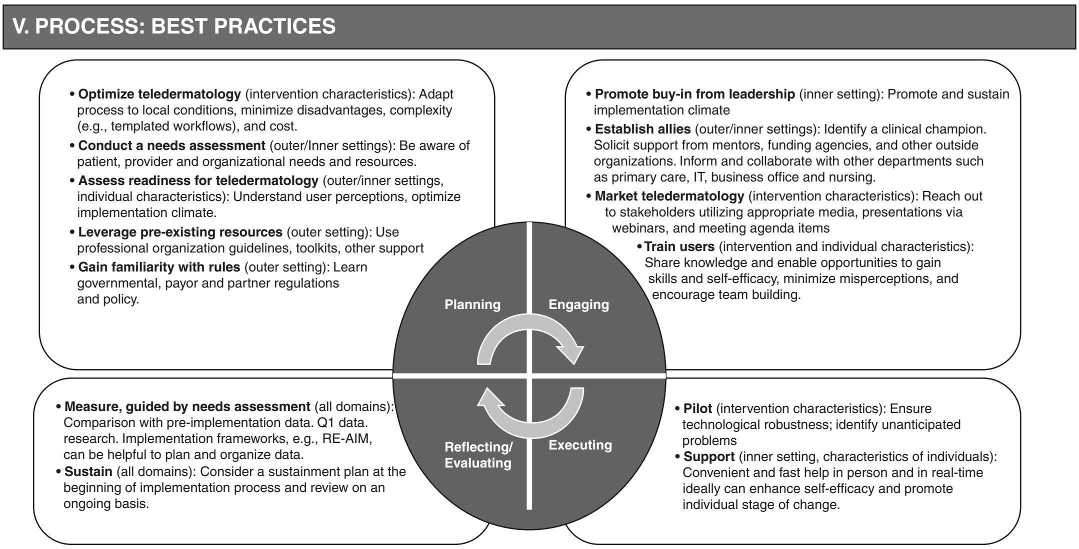

Fig. 7.1 CFIR Domain 5: teledermatology process best practices

Teledermatology Intervention Characteristics

Intervention characteristics generally are intrinsic features of the teledermatology process, though these include its ability to adapt to local contexts as we describe below.

Intervention source: Whether teledermatology programs are developed internally, within an organization, or by an outside group, and how these are perceived by stakeholders, may impact the success of the intervention. Teledermatology programs are typically developed internally and, although not all local clinics or family practitioners are involved in the development, they can be invited to join the initiatives, especially as they expand [28, 29]. Whether initiated internally or externally, the needs of the healthcare organization overall need to be considered to ensure long-term sustainability [30].

Evidence strength and quality: Considerable literature as well as scaled operational experience has provided both a scholarly foundation as well as real-world evidence for teledermatology implementation [31]. While many initial studies focused on diagnostic and management equivalence between teledermatology and in-person visits as well as patient and provider satisfaction, later studies, including randomized clinical trials, have also examined clinical outcomes and impacts on populations as well as organizational performance, including cost-effectiveness [32–35]. Such evidence may facilitate leadership buy-in and user acceptance by increasing the value that participants ascribe to the program, particularly if the program aligns with organizational goals [36–38].

Relative advantages and disadvantages: This construct focuses on stakeholder perceptions. Implementation can be modified by emphasizing positive perceptions and addressing problems underlying negative ones. Varied perceptions will be valued differently by each organization. A number of studies have described the pros and cons of teledermatology programs compared to usual in-person care, [39–41] as well as compared the different types of teledermatology to each other [42]. Benefits of asynchronous teledermatology can include reducing costs and improving efficiency for both providers and patients including reducing wait times, travel distance, and appointment completion rates for patients, and educating referring providers thereby improving diagnosis or management plans [43, 44]. While asynchronous teledermatology can provide better time management and quality images, synchronous video visits can allow better patient history acquisition and counseling regarding diagnosis and treatment of sensitive or complicated diagnoses [45].

Commonly perceived disadvantages include financial and legal concerns and problems of misdiagnosis due to poor image quality because of either poor video quality or lack of skill in taking still images [46, 47]. For asynchronous programs, in particular, practitioners are concerned that inaccurate or missing information may lead to a misdiagnosis [48]. Other disadvantages often raised relate to inadequate network connectivity either in clinic or for the patient remotely and the need for additional technical training by healthcare staff and patients [49]. Although not often considered, one study found some providers experienced increased mental distress due to patient expectations of immediate responses; communication of expectations is clearly important [50].

Adaptability: Teledermatology programs have developed to meet local needs throughout the world [51]. For example, in areas with limited access to in-person clinic visits, programs have used mobile phones and a variety of informal platforms including email, cloud-based file sharing, direct messaging applications such as WhatsApp (WhatsApp, Menlo Park, CA, USA), and social networking sites [52–54]. These platforms have been used not only within a country but also to link medical students and dermatologists internationally to increase access to areas with few dermatologists [55, 56]. Other adaptations include having a flexible or variable workflow to meet patient or provider needs (e.g., patient vs. clinic captured images, provider vs. staff-collected history), and the use of teledermoscopy and teledermatopathology to improve diagnostic accuracy [57–59].

Trialability/Piloting: Regardless of modality, teledermatology's ability to be tested for viability on a small scale is a valuable characteristic. Pilots allow for both staff and patients to build experience and expertise, such as gaining an understanding of usability of new technology [23, 28, 60, 61]. As a result, early adopters may serve as resources when the intervention scales. Furthermore, piloting may expose idiosyncrasies of the particular organizations or groups involved that were missed in the needs assessment. It is also often easier to fund pilots due to their smaller scale.

Complexity: While conceptually straightforward, teledermatology often introduces new technology, staff roles, and workflows that can affect stakeholders' views on the intervention's difficulty [62, 63]. Complexity can be measured by the number of steps needed to execute a teledermatology encounter or clicks required to use the software. It may also be increased by the number of decisions or branch points required, which may help to customize the process for users but can also create confusion and increase user effort. Involving practitioners in the design of the program provides an understanding of how applications and workflow can best fit the current practice, but problems may remain such as not taking into account the extra time required of practitioners [30, 64]. Scaling processes beyond a pilot phase also introduce additional layers of complexity. Even existing mature teledermatology programs can encounter new complexities such as integrating the program within the electronic health record system or adding the ability to use mobile apps to the program [23, 25, 29].

Design quality: In the context of CFIR, design refers to how a teledermatology program is presented and marketed. We interpret this to include the design of teledermatology technology itself, including user interfaces, and the resultant user experience. While applications may address basic program needs, barriers such as lack of compatibility with established electronic health records, difficulties with billing integration into existing systems, an inability for users to design their own templates, and the high overall cost of the applications have been reported [65]. To ensure that patient-facing technologies meet patient needs, the United States Veterans Health Administration (VA) has explored engaging patients directly in the design process [66].

Cost: Costs for patients, providers, and healthcare organizations are important factors in deciding whether and how to implement and sustain teledermatology. The majority of studies find teledermatology to be cost-effective from the patient, health facility or practice, and societal perspectives, primarily when considering patient travel distance, volume, and cost of usual care [67]. For societal analysis, time savings and convenience of a virtual visit have been examined [39]. Different business models exist with variable fees and reimbursement [68]. For example, for some large national health systems, partnerships with commercial entities are enacted to provide virtual care as is the case with England's National Health System [69]. In the United States, limited reimbursement for asynchronous teledermatology relative to synchronous teledermatology has been an implementation issue [70]. While the COVID-19 pandemic stimulated improvements, concerns remain [71].

Outer Setting

In this section, we examine political, economic, and social factors at the patient, provider, and organizational levels that influence the success of teledermatology programs.

Patient needs and resources: Teledermatology projects are often motivated by a desire to meet individual patient needs as well as those of a particular patient population, including the need to address access issues as reflected by patient wait times or distance traveled [28]. However, awareness of patient characteristics and capabilities can also be important. For example, remote mobile teledermatology interventions, which require that patients have access to specific resources such as smartphones or adequate Internet bandwidth, may not serve as many patients as planned [72, 73]. In an attempt to address this barrier within its own health system, VA expanded access to tablet devices and broadband in remote areas [74]. Age, living conditions, technological abilities, and social or religious concerns related to taking images may also impact adoption and use [75, 76].

Group relationships: Originally described as cosmopolitanism in CFIR, this feature describes the degree to which the implementing organization is networked to outside organizations. In the context of teledermatology, this might refer to the awareness by a practice or organization of the American Association of Dermatology (AAD) or American Telemedicine Association and its ability to leverage those organizations' resources. It can also include relationships or collaborations with other organizations with shared objectives such as funding agencies. For example, collaboration between the VA's Office of Connected Care, responsible for implementing teledermatology, and its Office of Rural Health, whose objective is to enhance healthcare for rural veterans, led to the establishment of a teledermatology funding program to support rural sites of care [22]. Similarly, partnerships between academic institutions in one country and international nongovernmental organizations or government entities in other countries have facilitated teledermatology-mediated care in low- and moderate-income countries [77, 78].

Peer influence: This construct, originally labeled in CFIR as peer pressure, includes leading by example, talks with colleagues at professional conferences, professional organizational endorsements, and groups of peers providing public support for teledermatology, and can lead to greater use. For example, AAD educates on and encourages the use of teledermatology, publishing guidelines and a toolkit to assist practices in implementing teledermatology programs. Other professional organizations such as the British Association of Dermatologists, the American Telemedicine Association, and the Australian College of Dermatologists also promote evidence-based guidelines [79, 80].

External policies and incentives: These can be strongly influential in the implementation of teledermatology. Legal, regulatory and reimbursement policies, for example, which protect patient privacy while also defining practitioners' risk can help stakeholders to accept teledermatology [81]. Concerns about liability can restrict teledermatology use, as was the case in the US prior to the COVID-19 pandemic, where practitioners also faced licensure limits and a lack of adequate insurance reimbursement. Recent changes to the regulatory landscape in the US have greatly increased teledermatology utilization, emphasizing the importance of these factors in implementation [82, 83].

Inner Setting

This domain recognizes unique aspects of the organization in which an intervention takes place.

Structural characteristics: Awareness of an organization's age, size, and social architecture (e.g., units responsible for supporting implementation) is important. Some large organizational and nationally driven teledermatology programs in the US, the Netherlands, and Australia have the resources and needs to develop their own systems, including electronic health records and billing platforms [64, 68, 84]. Nongovernmental organizations, loosely connected facilities, and individual practices tend to use commercially available platforms to provide either the entire program or specific facets such as mobile teledermatology [48, 51, 55]. One large private healthcare system has allowed some flexibility by having facilities choose the system that best fits their local context [85, 86].

For standard consultative asynchronous programs, which require general practitioners to initiate a consult with dermatologists and execute their recommendations, good working relationships are important, including enhanced communication and a quick provision of recommendations [87]. A program to enhance rural teledermatology found increased efficiencies when different clinician groups had a shared vision and an increased sense of being part of a team [88]. Such a relationship also benefits from clearly defined expectations and responsibilities for routine and emergency care. For example, VA requires a telehealth service agreement between these two groups [89].

Networks and communications: This concept embraces the quality of relationships within an organization. These extend beyond individual relationships, such as between a dermatology clinical champion to other stakeholders, to the quality of interactions between departments, including information technology, dermatology, and primary care, as well as leadership. Teledermatology as an inherently communicative intervention can facilitate communications and bonds. For example, a single case of teledermatology demonstrating its value to primary care can increase buy-in [90]. We have also found communications, such as messaging integration strategies to clinicians, was an important feature in mobile teledermatology implementation [23].

Culture: Culture refers to the overall stable atmosphere of an organization, including its norms and values. It is socially constructed and can influence the likelihood a teledermatology program will succeed. This might include a general legacy of supporting innovation and more specifically establishment of staffing or even a department responsible for managing telehealth. We are unaware of any reports examining organizational culture and teledermatology, and this may be an interesting area for future study.

Implementation climate: Distinguished from the concept of culture, this construct broadly refers to the capacity and receptivity for change within an organization or practice. Aspects of implementation climate, such as compatibility with the goals and mission of the organization as well as leaders' prioritization of teledermatology supported with resources and incentives, can lead to the normalization of the need for change and the resultant adoption of new technology and new workflows [23]. We recently studied one aspect of implementation climate as reflected by Organizational Readiness for Change, which in a limited sample size correlated with successful implementation [12, 23]. ORC is one component of OTIE that recognizes organizational policies and practices that can inhibit or promote an implementation climate [13, 91, 92].

Characteristics of Individuals

With important roles in the success of the teledermatology intervention, key stakeholders are patients, referring providers, dermatologists, and support staff. Their individual characteristics influence not only their own behavior but also the teams or sub-organizational units, such as group practices or departments, to which they belong.

Knowledge and beliefs: Attitudes about teledermatology can influence user choices and adoption. For example, dermatologists' use of different modalities may be driven by time constraints, possibly explaining the popularity of asynchronous over synchronous teledermatology. Referring providers may recognize the value of asynchronous teledermatology, though concerns about its perceived or real complexity and time demands can present a barrier and diminish it in their minds [87, 93, 94]. OTIE and the ORC recognize this valuation in the concept of change valence [12, 13]. As for patients, a facilitator is that they are generally satisfied with the care they receive via teledermatology and can believe their experiences are equivalent to face-to-face care [42].

Self-efficacy: This CFIR concept is also reflected in the ORC's incorporation of the organizational members' perceived ability to make changes necessary for implementation collectively (change efficacy). Referring providers sometimes lack self-efficacy, the belief in their capacity to manage their patient's treatment using teledermatology, which can be a barrier [87]. Ongoing educational programs increase referring providers' competency and confidence in dermatology as does increased participation in teledermatology [88].

Individual stage of change: The degree of engagement and expertise of individual stakeholders in using teledermatology is expected to change as implementation progresses and reflects program success. This construct does not appear to have been explicitly studied for teledermatology but may be an important area to examine as individual change may facilitate peer influence.

Identification with organization: As staff increasingly identify with an organization, their commitment to successful implementation of an intervention may increase. This trait's importance has not been well-studied in telehealth, and it is generally not under the control of an implementation project. However, it may be helpful in guiding how to present teledermatology to users. For example, the implementation of telemedicine in organizations such as the military and VA are often tied to their strong missions to provide care for their patients [38, 95].

Process

The actual process by which teledermatology is deployed to users ideally integrates the perspectives of and knowledge learned from other CFIR domains (Fig. 7.1).

Planning: Pre-implementation steps will vary based on factors discussed under the domains above, including the type of teledermatology being introduced, and the local context [96–98]. A typical and important initial step is to conduct a needs assessment of all stakeholders. Assessing both patients' and organizational readiness may add further valuable information [30, 77]. We are not aware of validated patient readiness tools, but the ORC survey score is one measure of an organization's commitment and efficacy to change [24] and to gauge its likelihood of success [25]. It is also ideal to create an evaluation plan, particularly to collect comparative data before the program starts.

Engaging: Recruiting and partnering with key individuals (local administrative and clinical leaders, support staff who oversee execution of implementation tasks, and clinical champions who have a direct stake in teledermatology's success) are important [25]. Clinical champions, either dermatologists or referring providers, can have a positive effect on a teledermatology program with enthusiastic and sustained support of the program, and by serving as an information resource [23, 99]. It may also be important to engage groups or individuals that are external to the organization but critical for the functioning of the program such as consultants or contractors, especially those that provide marketing and technical support [25]. Training of staff will also need to be developed to understand new workflows, even if minor, or to develop new skills needed such as how to take appropriate images.

Executing: Evaluating the quality of teledermatology execution can include the fidelity of operations to the pre-implementation plan, achievement of critical milestones and their timeliness, and the engagement of stakeholders, and ultimately the achievement of program goals (see Reflecting and evaluating below). A pilot is beneficial to identify problems and seek user feedback before scaling. In South Africa, researchers recommended sequentially executing an implementation roadmap to achieve sustainability so that complexities, such as the need to incorporate local objectives, can be incorporated into the roadmap as they arise [96].

Support is important to improve the skills of practitioners, particularly in remote areas, and to alleviate concerns. In the United States, the Dermatology Extension for Community Healthcare Outcomes project assists general practitioners in the treatment and management of skin diseases, creating a community of practice so that participating providers can receive guidance and mentoring [100]. One study found preliminary evidence that having staff serve as in-person assistants or improvement coaches increased usage of mobile teledermatology as they encouraged use, served as an on-demand problem-solving resource, and communicated best practices [25].

Reflecting and evaluating: Monitoring may be guided by the needs assessment, and may be part of existing quality improvement processes or research activities for more systematic evaluations. Common measures for teledermatology have included user (patient or clinician) feedback and satisfaction, access to care including timeliness of care and geographic access, populations impacted, avoidance of in-person visits, and costs [101]. The RE-AIM framework emphasizes empirically measured endpoints, and importantly explicitly includes the concept of sustainability, implying a longitudinal measure of a program's activity instead of focusing only on initial implementation successes. Following a framework such as CFIR helps to ensure that a program identifies and reinforces facilitators while minimizing barriers. Through continuous learning about the program and recognition that the intervention process benefits from being dynamic, teledermatology will more likely become a sustained program.

Summary

Teledermatology has evolved from isolated demonstration projects to a successful and common modality of care. Implementation frameworks such as CFIR provide a theory-based approach to comprehensively understand the factors underlying program successes and failures. These frameworks have generally been designed as research tools to analyze and learn from prior performance, and they suggest a number of areas for future investigation and research. However, they may also be useful guideposts for planning and implementing teledermatology operations which will be increasingly important as practices and healthcare organizations seek to start, expand, and sustain their teledermatology activities.

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Conflict of Interest The authors declare no conflict of interest.

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Teledermatology: Legal and Regulatory Considerations

8

Pranav Puri and Mark R. Pittelkow

Introduction

In recent years, advancements in telecommunications have transformed industries ranging from retail to media to finance. Yet prior to the COVID-19 pandemic, healthcare was relatively insulated from the massive digital disruption seen in other sectors [1]. In part, this was due to healthcare's high level of legal and regulatory complexity. For example, even though dermatologists were at the forefront of adopting telemedicine before the pandemic, more than 80% of dermatologists did not routinely use teledermatology services in 2016 [2]. Moreover, dermatologists most frequently cited legal and regulatory concerns as primary barriers to increased teledermatology adoption [3]. To this end, teledermatology use increased dramatically following the onset of the COVID-19 pandemic as numerous legal and regulatory restrictions were relaxed.

In the United States, telehealth services are governed by laws, regulations, and policies administered at both the federal and state levels—thus the adage, "fifty states, fifty approaches." The legal and regulatory environment for telehealth is highly dynamic at both the state and federal level, particularly as temporary waivers related to the COVID-19 pandemic expire and more permanent legislation is codified.

In this chapter, we provide an overview of key legal and regulatory considerations as they pertain to the practice of teledermatology. Since this content matter is rapidly evolving, we aim to provide an understanding of general principles and trends, rather than minutiae of specific laws and statutes.

Licensure

In the United States, medical and telehealth licensing requirements are subject to a patchwork of state-level regulations. Each of the 50 state-level boards of medicine regulates physician licensure in their respective states. This has important legal and financial consequences for dermatologists, especially those who seek to practice across state lines.

Most state "practice of medicine" laws require providers to be licensed in the state in which the patient is located. The "practice of medicine" typically includes, but is not limited to, the diagnosis, examination, treatment, or other direction of medical care to a patient [4]. For example, if a dermatologist in Arizona conducted a video visit with a patient living in Illinois and wrote a prescription for a topical steroid, the encounter would be subject to state-level "practice of medi-

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cine" laws. Notably however provider-to-provider consultations are not typically considered "practice of medicine." Therefore, if the above example was modified such that the patient's primary care physician in Illinois directly conducted a video call with the dermatologist in Arizona to discuss the patient's treatment options, this interaction would not be subject to "practice of medicine" laws, so long as the patient was not present during the video call.

During the onset of the COVID-19 pandemic, most states waived their in-state "practice of medicine" licensure requirements to expand access to remote care and alleviate the burden on in-person healthcare resources. Similarly, some states granted temporary licenses to out-of-state providers. These policy measures were often enacted as part of state public health emergency (PHE) declarations.

In 2021 and 2022, states began to modify policy responses to the COVID-19 pandemic, which had downstream effects on state-level licensure requirements. For example, in June 2021, Florida allowed its PHE declaration to expire. Under Florida's PHE, providers who were not licensed in Florida were allowed to provide telehealth services to patients physically located in Florida [5]. Since the expiration of Florida's PHE, out-of-state telehealth providers have been required to obtain licensure in Florida. However, Florida has facilitated long-term licensure for out-of-state telehealth providers by creating a separate abbreviated licensing process for telehealth services. Similar expedited telehealth licensing pathways for out-of-state providers have been created in states such as Arizona, West Virginia, Minnesota, and Connecticut [6].

In addition, the Interstate Medical Licensure Compact (IMLC) has recently gained momentum as an additional pathway to facilitate out-of-state licensure [7]. The IMLC is a binding agreement between state medical boards that allows physicians to apply for licensure in multiple states through a unified and streamlined application process. As of August 2022, the IMLC includes 34 states, the District of Columbia and the Territory of Guam. Providers who meet the IMLC's qualification requirements receive separate licenses from each state they intend to practice in. Therefore, the IMLC does not provide a national license per se, but rather is a streamlined application process for gaining licensure in individual states.

Although PHE declarations and licensure waivers during the COVID-19 pandemic led to significant growth in interstate telehealth services, this was in part because these policy changes did not require any further action from providers. However, as these temporary measures expire, providers must remain familiar with the most recent state-level licensure policy changes.

Taken together, the status quo state-by-state licensing approach imposes significant regulatory burdens in terms of financial cost, time, and resource utilization. For example, a group practice of 10 dermatologists seeking to provide teledermatology services to its patients nationally would need to apply and pay for 500 separate licenses. Therefore, the complexity of the existing licensure process creates disincentives for the wider adoption of telehealth services. In addition, this piecemeal approach to licensure may also have broader economic consequences to the degree licensure barriers restrict competition in certain markets [8]. Consequently, providers, patients, and policymakers would be well-served by the creation of a more robust and simplified national licensing framework.

Malpractice Coverage

Prior to rendering teledermatology services, dermatologists should carefully review their malpractice insurance coverage policy. Although relatively few cases of medical malpractice associated with teledermatology have been reported in the literature [9, 10], dermatologists should ensure that their existing malpractice insurance clearly stipulates policies regarding telehealth services, both within their state and across state lines. If existing coverage is inadequate, supplemental coverage for teledermatology services may need to be purchased. Malpractice insurance is regulated at the state level, so coverage requirements vary across states. In addition, since physical examinations are inherently limited in teledermatology encounters, dermatologists should exercise increased caution to mitigate liability exposure. Moreover, standard of care definitions may vary across state jurisdictions, which creates additional liability risks [11].

Privacy and Security

Since teledermatology inherently involves the digital transmission of health information and given the increasing prevalence of cyberattacks targeting healthcare institutions, dermatologists should maintain a heightened awareness of threats to patient privacy and data security when practicing teledermatology [12]. Therefore, the provision of teledermatology services must comply with federal and state laws governing the privacy and security of protected health information (PHI). PHI is generally defined as any information used within a healthcare setting that could be used to identify an individual patient [13].

The Health Insurance Portability and Accountability Act (HIPAA) was enacted in 1996 and is the primary federal legislation governing standards of PHI protection. In short, HIPAA protects PHI through two key provisions: its privacy rule and its security rule. Under HIPAA's privacy rule, providers must take "reasonable steps to limit the use or disclosure of, and requests for [PHI] to the minimum necessary to accomplish the intended purpose" [14]. Under HIPAA's security rule, providers must "ensure the confidentiality, integrity, and availability of all electronic-PHI they create, receive, maintain or transmit" and "identify and protect against reasonably anticipated threats to the security or integrity of the information" [14].

Consequently, software used for telemedicine purposes (i.e., electronic health records, videoconferencing software, etc.) is legally required to meet the data safety and privacy standards established by HIPAA. These standards are often colloquially referred to as being "HIPAA compliant." Dermatologists, in particular, should be mindful that the capture, transmission, and storage of clinical images is in accordance with HIPAA statutes.

Notably, HIPAA establishes a minimum regulatory standard by which all states must comply, yet many states have enacted privacy and security laws with more stringent requirements. Similar to state-level licensure requirements, dermatologists must ensure they comply with the state-level privacy and security laws governing their own location as well as those governing the patient's location. For example, some state laws require telehealth providers to deliver a copy of the patient's medical record to the patient or their primary care provider following the telehealth encounter [15].

At the onset of the COVID-19 pandemic, the Office of Civil Rights at the Department of Health and Human Services (HHS) issued a notice of enforcement discretion which temporarily relaxed the enforcement of numerous federal privacy and security regulations [16]. This notice was issued to rapidly increase access to telehealth services and reduce the administrative compliance burden on providers—many of whom were inexperienced with telemedicine. Under this notice, providers were allowed to use non-HIPAA compliant platforms (i.e., FaceTime® [Apple, Cupertino, CA], WhatsApp® [Meta, Menlo Park, CA], etc.) for telemedicine services for the extent of the federal public health emergency, so long as the noncompliant platforms were used in good faith. Although HIPAA penalties have been waived for the extent of the public health emergency, these waivers will eventually expire, and enforcement of HIPAA will recommence. Therefore, dermatologists interested in maintaining active teledermatology practices would be prudent to adopt telehealth platforms with robust privacy and cybersecurity capabilities.

Insurance Coverage and Reimbursement

The United States healthcare system is an amalgam of nonprofit, for-profit, and government providers, with both public and private payers providing health insurance coverage. Individuals younger than 65 years of age predominantly receive healthcare coverage through private health insurance plans. Individuals 65 years of age and older are primarily insured by Medicare, a federally funded public health insurance program. Low-income individuals receive health insurance coverage through Medicaid, which is a program administered at the state level with the assistance of federal funding. Veterans of the US military receive healthcare through the Veterans Health Administration, a federally funded integrated health system which is similar to the National Health Service in the United Kingdom or other nationalized single payer systems. High-level features of each of these payers and their telemedicine policies are summarized in Table 8.1.

Although each of the aforementioned payers has its own specific policies for telehealth coverage and reimbursement, Medicare is the nation's largest payer and its regulations and reimbursement rates often form the basis for policies adopted by other payers. Therefore, an understanding of Medicare's telemedicine policy dimensions and regulatory frameworks sheds light on more generalizable trends.

Prior to the COVID-19 pandemic, Medicare policies on telemedicine coverage were quite restrictive, with only 0.3% of traditional Medicare beneficiaries receiving telehealth services in 2016 [17]. Telemedicine services were only available to beneficiaries residing in rural areas, and telehealth services were required to originate from a healthcare setting, i.e., clinic or doctor's office. This meant that beneficiaries could not receive telehealth services in their own home. Furthermore, most telehealth visits were required to be live-interactive sessions conducted using a two-way audio-video communication system, but notably use of smartphones was not permitted.

In 2019, Medicare allowed providers to be reimbursed for brief virtual patient check-ins

Table 8.1 Teledermatology coverage and reimbursement policies of major payers

	Medicare	Medicaid	Veterans health administration	Private insurance
Patient demographics	Adults age 65+ and certain residents with disabilities	Low-income adults and children	Members of the military	Primarily employer-sponsored insurance for employees and their families. Individuals can purchase e on the marketplace.
Funding source	Federal program. Medicare advantage (MA) plans are administered by private insurance companies. Insurers are paid a lump-see fee per enrollee	Funded by both federal and state governments	Federal program	Primarily private. Subsidized by the federal government through tax incentives
% of US population	15%	18%	3%	55%
Teledermatology coverage	Primarily live-interactive. Store-and-forward and virtual check-ins also covered but at lower reimbursement rates	Varies by state. All states cover live-interactive. Some cover store-and-forward	Primarily store-and-forward. Live-interactive as well	Varies by insurance company and state. Most cover store-and-forward as well as live-interactive
Payment models	Primarily fee-for-service. Some value-based payment models such as accountable care organizations and bundled payments.	Primarily fee-for-service	Fully integrated system. Physicians are salaried.	Primarily fee-for-service
Reimbursement rates	$$	$	___	$$$

using patient portals, email, or store-and-forward images [18]. These virtual check-ins were not subject to the originating site restrictions described above. Nonetheless, virtual patient check-ins were not broadly adopted, likely due to their relatively low reimbursement rates. For example, in 2019, store-and-forward services were reimbursed at approximately $13 per service, whereas an in-person office visit could have been reimbursed up to $148 [8]. This was representative of Medicare's general approach of paying lower rates for telehealth services as compared to corresponding in-person services.

At the onset of the COVID-19 pandemic, HHS issued several temporary waivers that relaxed restrictions on Medicare coverage of telehealth services for the extent of the PHE (Table 8.2). Notably, beneficiaries residing in any geographic area were allowed to receive telehealth services and were allowed to do so from their homes using smartphones and other personal devices. In addition, telehealth services were reimbursed as if they were provided in-person.

In response to Medicare's adoption of telehealth payment parity, most private payers and state Medicaid plans followed suit by issuing their own temporary payment parity waivers. Furthermore, as of August 2022, 26 states have passed legislation mandating insurers to provide payment parity (Fig. 8.1) [19]. These state-level mandates come in several forms, with some states requiring payments to be "on the same basis" as in-person care, while other states require payments to be "not less than" or "not more than" in-person care.

Although these distinctions in nomenclature may seem esoteric, they could have profound impacts on telehealth markets to the degree they could result in either price floors or price ceilings. Critics of payment parity provisions argue that since private-payer negotiated rates for telehealth visits have historically been less than in-person visits, payment parity mandates will serve as price floors, artificially setting reimbursement rates higher than market rates and resulting in overuse of telehealth services.

Table 8.2 Medicare regulatory changes related to COVID-19

	Regulatory change	Effect
Payment	Telehealth services were reimbursed as if they were provided in-person	Incentivized increased adoption of telehealth services
Privacy	Penalties for HIPAA violations that occur in good faith were not enforced	Allowed clinicians to use platforms that are not HIPAA compliant such as facetime and WhatsApp
Licensing	Out-of-state licensure requirements were not enforced	Enabled clinicians from out-of-state to practice via telehealth
Location	Patients were not required to reside in a rural area or originate services from a healthcare setting	Enabled patients to receive telehealth services from their homes
Cost-sharing	Providers were not required to collect copayments and deductibles from patients	Reduced out-of-pocket expense for patients
Modality	Patients were not required to conduct live-interactive sessions using two-way audiovisual systems	Enabled patients to use smartphones. Patients without Internet access were able to receive audio-only services

Meanwhile, proponents of payment parity mandates argue that if telehealth services are reimbursed at lower rates than in-person visits, then providers will be disincentivized to use telehealth in relation to in-person services [20]. This is particularly salient for procedural specialties such as dermatology where in-person visits generate additional revenue through procedures. Nonetheless, given the economics of fee-for-service payments, future utilization of telehealth services will be significantly influenced by policies governing reimbursement rates. Therefore, the value of telehealth services might be best quantified through the study of population-based payment models where providers themselves decide how much to pay for in-person versus telehealth services.

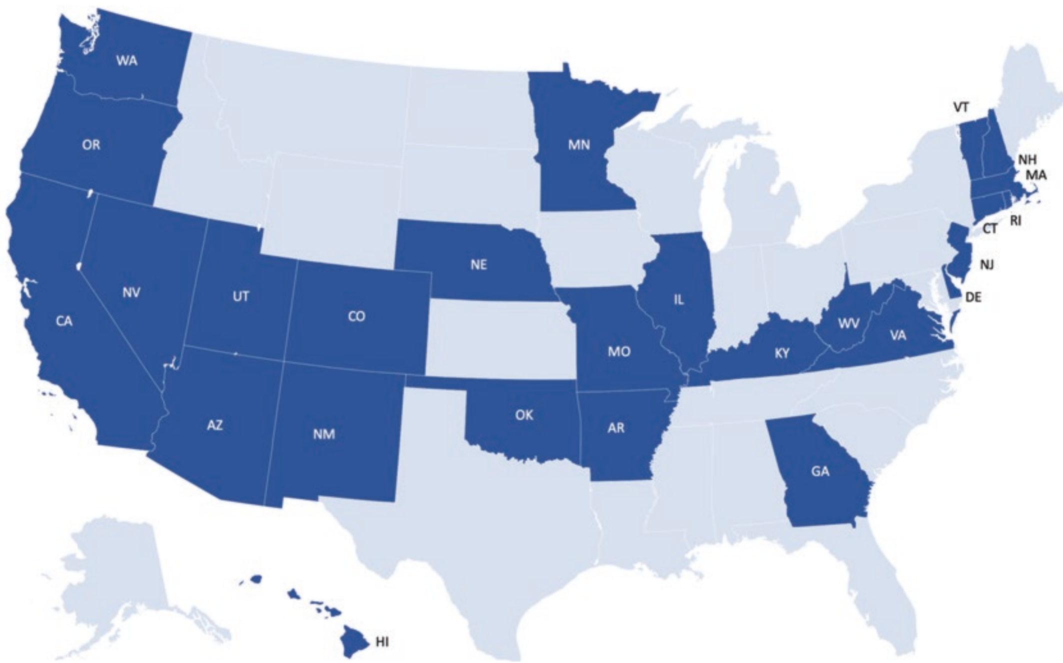

Fig. 8.1 States with laws requiring insurers to implement payment parity for telehealth services as of August 2022 [19]. **Massachusetts: parity for mental health services only; Nebraska: parity for mental health and substance use services only; New Jersey: parity approved only through December 31, 2023; West Virginia: parity only for established patients and patients in acute care facilities**

Conclusion

The regulatory and legal frameworks governing teledermatology are complex, vary significantly based on state and payer type, and are evolving rapidly. Therefore, dermatologists should stay apprised of the most recent state and federal telehealth regulations. Exhibit 8.1 highlights frequently updated resources with information on both federal and state-specific telehealth regulations. However, as general principles, dermatologists should ensure the following:

1. They are licensed to practice both in their own physical location as well as the patient's.
2. They have adequate malpractice insurance that covers the provision of telehealth services across state lines.
3. PHI is protected to the same standards as in-person care, and any software used for teledermatology is fully compliant with HIPAA.
4. Teledermatology services are appropriately documented and billed to meet payer-specific requirements for reimbursement.

Exhibit 8.1:
Up-to-date resources on state-specific telehealth regulations

Telehealth.hhs.gov
FindLaw.
American Telemedicine Association.
Center for Connected Health Policy.
Kaiser Family Foundation.

Conflict of Interest The authors report no relevant conflict of interest.

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9 Teledermatology: Clinical Practice Guidelines

Edwin Dovigi and Joseph C English III

Introduction

Guidelines for clinical practice are ubiquitous throughout healthcare. The development of clinical practice guidelines (CPGs) is often undertaken for the purpose of providing healthcare practitioners with a set of recommendations to assist with clinical decision-making [1]. Influences from professional regulatory bodies, patients, and healthcare payers also play a necessary role in guideline development. As such, in addition to the best available clinical evidence, the perspectives of multiple stakeholders, including healthcare practitioners, patients, healthcare payers, and regulatory bodies are often considered during guideline development, which can improve guideline quality [2].

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Teledermatology Clinical Practice Guidelines: Content

A 2011 review article identified over 200 CPGs published in the field of Dermatology [3]. In addition to dermatological conditions, a number of guidelines exist to offer recommendations on optimizing care delivery within dermatology, including through teledermatology. Teledermatology has multiple modalities, including synchronous (i.e., real-time interaction between a dermatologist and a referring physician or patient), and asynchronous (also called "store-and-forward" teledermatology, where images are sent to a dermatologist who reviews them and makes recommendations) formats. These modalities can be combined into a "hybrid" format, where images are first sent to a dermatologist who reviews them, and then follows up with the referring physician or patient real time via a telephone or video encounter. Teledermatology encounters can be between a referring clinical provider and a dermatologist, or from a patient to a dermatologist (often termed, "direct-to-consumer" teledermatology).

Between 2016 and 2020, three practice guidelines have been developed by national dermatology organizations located in the United States, the United Kingdom, and Australia [4–6]. Earlier iterations of some of these guidelines have been published previously as well [7]. In addition to formalized guidelines, multiple institutions,

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including the American Academy of Dermatology (AAD), have developed position statements and sets of standards to facilitate the provision of teledermatology as well [8, 9]. Most institutional guidelines and position statements share similar content and include features such as a guideline purpose statement, patient selection criteria, patient privacy and medicolegal considerations, and minimum technology requirements. These features are summarized below.

Broadly, the stated purpose of teledermatology guideline development across national institutions is to provide dermatologists with a reference for effective and safe teledermatology use [4–6]. Much has been published on the effectiveness of teledermatology for various dermatology conditions, including for pigmented versus non-pigmented lesions, total-body skin exams, mucosal lesions, hair-bearing body surface lesions, etc. These considerations affect patient selection for teledermatology. Regarding pigmented lesions, for instance, the British Association of Dermatologists recommends a provider trained in the use of dermoscopy to take dermatoscopic images to send to dermatologists via asynchronous "store-and-forward" teledermatology [4]. And so by extension, the evaluation of pigmented lesions may not be appropriate in exclusively live-interactive or direct-to-consumer teledermatology formats but would be appropriate in a hybrid format where real-time interactive follow-up is provided after image review. This recommendation is shared by the University of Queensland and the Australasian College of Dermatologists, who recommend the use of store-and-forward teledermatology for pigmented lesions only if dermatoscopic images are provided with the referral. The American Telemedicine Association states that diagnosing pigmented lesions can be challenging and that the use of dermoscopy and/or confocal microscopy may be of assistance. Similarly, these considerations would apply to total-body skin exams as well, as any pigmented lesions revealed may benefit from dermatoscopic evaluation. Based on these evaluations and recommendations, with adequate images, store-and-forward teledermatology may be used to triage patients with pigmented lesions for in-person evaluation and potential biopsy as well. For hair-bearing anatomical locations, guidelines suggest that hair be displaced or moved and be assessed under sufficient lighting (American Telemedicine Association), or mere caution that hair-bearing and mucosal locations may be difficult to image and that the dermatologist should consider if patients would be better suited to be evaluated in person. Finally, patient preference should also be taken into consideration when recommending teledermatology versus in-patient visits [4]. All of these considerations affect patient selection.

Patient privacy and medicolegal risk assessment also receive considerable attention across CPGs and position statements. Common considerations across practice landscapes and countries include ensuring malpractice/indemnity insurance covers teledermatology visits, obtaining informed consent which includes informing the patient of all available care options and potential associated risks in their preferred language, placing consent documentation in patient's chart if possible, ensuring a chaperone or legal guardian is present during the encounter as appropriate, adhering to relevant professional guidelines and laws, keeping accurate and contemporaneous documentation of patient visits [4–6]. All guidelines also stress the importance of secure capture and storage of digital images through encryption, as well as obtaining patient consent and confirming patient identification prior to image capture. The AAD, for instance, recommends 128-bit encryption of all images delivered and password-level authentication.

Technology recommendations are also reviewed in detail in each of the three CPGs. In brief summary, store-and-forward teledermatology recommendations include digital image size of at least 0.8–3 MP with a preference of 8MP [4], automatic white balance, flash on, and consistent image settings within and across patients, and minimal image compression (no more than 20:1 for JPEG images) [7]. General photography recommendations include avoidance of backlighting, using a solid neutral background color, removal of jewelry, and, if applicable, clothing. All images should be taken perpendicular to the lesion. Guidelines also recommend capturing multiple images. Two close-range images of the lesion approximately 20 cm from the skin surface should be taken [5], and at least one mid-range image that includes an anatomical marker (e.g., navel, joint, etc.), as well as one distant image of the entire body part containing the lesion (arm, leg, torso, etc.) [5]. Additional recommendations have been provided for dermatoscopic images. Dermatoscopic images should be captured at the same orientation as photographic images (i.e., cranial part of the lesion is superior in the frame), lesions should have a scale or size marker in the frame, polarized light should be used with or without additional images captured with non-polarized light as needed. Dermatoscopic images should be captured by individuals trained in dermatoscope use. For live-interactive teledermatology, video should be capable of connecting at 384 kbps running 4CIF@30fps as per the British Association of Dermatologists and AAD, with an advanced video compression standard of H.264 or higher.

For teledermatology visits initiated by a referring provider, each guideline also provides recommendations. The British Association of Dermatologists recommends that for chronic inflammatory conditions such as psoriasis and eczema, the referring provider should have access to the facilities and necessary clinical experience to provide the patient with ongoing support given the need for intermittent, long-term management. Additionally, as per the American Telemedicine Association, providing referring providers with an explanation of clinical signs that may signify an exacerbation of a condition is also recommended. If the dermatologist requests lab work or follow-up diagnostic study, this should be followed up by the dermatologist and communicated with the referring provider and patient in a timely fashion. Responsibilities for each aspect of patient care following a teledermatology consult should also be established and communicated between providers. As per the AAD position statement, referring providers may elect to accept recommendations provided in part, in whole, or not at all, with the liability and responsibility shared based on the extent to which recommendations are followed [9]. Finally, as stated above, all communications between providers should be through a secure format.

The British Association of Dermatologists as well as the American Academy of Dermatology recommends periodic assessment of the originating and consultant teledermatology site, at a minimum of yearly, as a quality control measure [5, 9]. Part of this quality control assessment includes patient satisfaction surveying, which is also recommended to be performed at least once per year [5].

Teledermatology Clinical Practice Guidelines: Appraisal

Clinical practice guideline appraisal tools have been developed for the purpose of assessing guideline quality and ultimately, guideline development through internal quality assessment. A systematic review of CPG appraisal tools has identified the following core features of CPGs that mark guideline quality: systematic evidence collection and evaluation, cost-effectiveness considerations, facilitators and barriers to implementation of guideline recommendations, independence of guideline development, and presentation of guidelines [10].

A detailed appraisal of each of the three national teledermatology practice guidelines highlighted above was conducted in 2022 using the Appraisal of Guidelines, Research and Evaluation (AGREE II) framework [2, 11]. This framework has been identified as the most comprehensive and validated CPG appraisal tool [10]. The AGREE II framework appraises CPGs across six domains: scope and purpose, stakeholder involvement, rigor of development, clarity of presentation, applicability and editorial independence. Although the AGREE II framework is not designed to evaluate the clinical appropriateness of recommendations within CPGs, high-quality scores have been shown to predict guideline adoption, endorsement, and overall quality [2].

In reviewing teledermatology CPGs, it was found that each of the three practice guidelines demonstrated unique strengths [11]. For instance, the Australasian College of Dermatologists was the only national group to detail a systematic review of evidence during their guideline development process. The British Association of Dermatologists involved the broadest range of relevant stakeholders in their guideline development process, including dermatologists, general practitioners, medicolegal representatives, media resource specialists, and patient representatives. Finally, the American Telemedicine Association offered a clear scope and purpose of their guidelines with clear and concise objectives. Also, in reviewing the American Academy of Dermatology's position statement, the recommendations provided are clear, concise, and accessible and as such, would score highly on the Clarity of Presentation domain of the AGREE II framework [8].

Areas for improvement were also identified, particularly in the rigor of development and editorial independence domains. Of all teledermatology clinical practice guidelines published to date, only the guidelines published by the Australasian College of Dermatologists documented a systematic review of evidence used to inform guideline recommendations. Defining evidence inclusion and exclusion criteria, detailing how evidence was weighed when formulating recommendations, and the extent to which stakeholder involvement was leveraged when discussing evidence would have improved the rigor of the development of all guidelines.

Regarding editorial independence, there are two main considerations that arise when appraising CPGs. The first and most prevalent concern is the underreporting of guideline developer conflict of interest, which has been demonstrated to be a systemic issue across multiple disciplines [12]. Not reporting or underreporting conflict of interest makes it challenging for guideline stakeholders to evaluate the editorial independence of guideline developers and gauge the extent to which recommendations are influenced by financial, intellectual, or other biases [13]. When conflict of interest are reported, the next issue that arises is how to assess their possible influences on recommendations. Although CPG appraisal tools provide scores for editorial independence pertaining to the documentation and discussion of conflict of interest, there is limited guidance on how to appraise the effects of potential conflicts. Working groups devoted to assessing conflict of interest have been assembled and have created a list of "red flags" that may indicate that potential conflict of interest affect guideline recommendations. Items in this list explore the developer's ties to sponsors with substantial industry funding or proprietary healthcare companies, as well as investigate evidence suggestive of "committee stacking" during panel assembly [13].

Of the three teledermatology CPGs reviewed, the American Telemedicine Association and the Australasian College of Dermatologists provided a disclosure statement stating authors had no competing interests to declare. Funding statements were provided by the Australasian College of Dermatologists and the British Association of dermatologists. Authors associated with the Australian guidelines also disclose other interests, which include shareholder and consultant relationships with various teledermatology companies, including MoleMap NZ, and e-derm consult GmbH. No further exploration of the relationship between funding bodies and recommendations was provided.

Teledermatology Clinical Practice Guidelines: The Future

Guideline development is an iterative process. Advances in smartphone technology, data storage, and transmission, as well as medicolegal and medical practice model shifts precipitated by the COVID-19 pandemic, have contributed to a rapidly changing telemedicine landscape. As existing CPGs in teledermatology have been published prior to many of these changes, dermatologists are currently well-positioned to develop the next iteration of CPGs. Consistent with a new era in guideline development, the American Academy of Dermatology (AAD) also recently recommended the adoption of the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) framework—a widely adopted CPG development tool that provides strength of guideline recommendations tied to the evidence quality supporting recommendations [14, 15]. Employing systematic evidence collection methods and evidence quality grading using the GRADE framework would allow for rigorous guideline development and ultimately improve guideline appraisal scores, a key area of existing teledermatology CPGs needed for improvement [15].

New guidelines will also devote a section to exploring editorial independence, including details on guideline developer panel makeup, a full disclosure of potential financial and intellectual conflict of interest, as well as an exploration of any potential conflict of interest that may influence recommendations. In 2020, the AAD published a statement that 51% of CPG guideline developers within a working group must not have relevant financial interests when developing CPGs [14]. It may be of additional importance for guideline developers not to receive payment from industry sponsors in a fixed term after guideline development, as a 2022 study found that some CPG developers in dermatology receive industry payments shortly after guideline publication (i.e., within 2 years) [16]. If no conflict of interest are present to declare, a more useful disclosure statement may be to the effect of, "author has no financial ties to proprietary healthcare companies and receives no industry funding," rather than "no conflict of interest to declare." If financial ties are present, a brief detailing of safeguards designed to prevent outside influence may be beneficial to stakeholders interpreting guidelines; for example, by providing how existing evidence is used to formulate recommendations, publishing other guideline developer and patient perspectives, etc.

With advancing technology and the persistence of a pandemic environment, both the ability to provide and the need for teledermatology services have never been greater. Rigorously developed and accessible teledermatology guidelines may facilitate the provision of a high-quality standard of care in teledermatology.

Conflict of Interest The authors have no financial ties to proprietary healthcare companies and no other conflict of interest to declare.

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10 Teledermatology: Outcomes for Skin Lesions

Emily Clarke, Ayisha Mahama, Lia Gracey, and Anokhi Jambusaria-Pahlajani

Introduction

Teledermatology is a useful tool to evaluate skin lesions. There are two main modalities of teledermatology that can be utilized including live interactive (synchronous) teledermatology and store-and-forward (asynchronous) consultation ("teleconsults" or "e-consults"). While live interactive teledermatology occurs in real-time, store-and-forward teledermatology involves transmitting information and photographs for asynchronous review. A hybrid teledermatology system combines synchronous and asynchronous methods as needed. Compared to inflammatory disorders, skin lesions are more discrete, limited to one anatomic site, and more easily photographed, therefore lending themselves well to teledermatology.

There have been numerous studies published about teledermatology for skin lesions, especially as teledermatology has gained popularity clinically. However, current studies are significantly varied in design and outcomes, which can make drawing conclusions and comparing them challenging. It is important for dermatologists and primary care physicians (PCPs) to better understand the benefits and limitations of teledermatology for skin lesions before implementing its use. The goal of this chapter is to review the current literature about the applications and outcomes of teledermatology for skin lesions.

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Practical Applications

Teledermatology for skin lesions has been used in a variety of settings including teletriage, provision of rural care, preoperative evaluations, and delivery of care to underserved patients. It can increase access to specialists, particularly when wait times for specialist consultation are long.

In many dermatology practices, during the coronavirus disease 2019 (COVID-19) pandemic, teledermatology was an essential tool to provide care to patients while reducing human-to-human contact and potential disease spread. A web-based survey of over 700 dermatologists in multiple countries found that the percentage of dermatologists using teledermatology increased by three-fold from 26% to 75% during the pandemic [1].

Teledermatology can be utilized to triage cases based on disease severity to allocate limited resources appropriately, termed "teletriage." Studies in the inpatient and outpatient setting

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have demonstrated that successful teletriage can lessen patient wait times [2] and reduce potentially unnecessary face-to-face visits [3]. Teledermatology can also triage lesions concerning for skin cancer to determine a need for in-person evaluation and biopsy [4]. In the authors' academic practice, teletriage has successfully reduced the wait times at a "safety net" dermatology clinic from over six months to several weeks.

Teledermatology helps to provide access where dermatology care is scarce, such as rural areas and underserved urban patient populations. In rural areas, patients can wait months to years prior to evaluation [5] and many countries have implemented teledermatology programs to expand care to these underserved communities [6–10]. One pilot program utilized mobile phone-based store-and-forward teledermatology to improve access for underinsured patients in urban areas [11]. Several studies have evaluated teledermatology in primary care, which improved access to specialists [12–15]. A study at a "safety net" hospital demonstrated that store-and-forward teledermatology decreased time to evaluation from 70 days to less than a day [16]. Teledermatology can also reduce potential unnecessary in-person visits and no-show rates [17].

Store-and-forward teledermatology appears to be a viable option as a "screening test" to determine whether a concerning lesion requires further evaluation, with one study demonstrating a reported rate of 100% sensitivity for skin cancer detection [18]. Another interesting application is preoperative consultation before Mohs micrographic surgery, which can reduce time to treatment by weeks [19, 20]. There is a high agreement between planned surgical techniques and those utilized on the day of surgery [20], suggesting teleconsultation is helpful in creating a preoperative plan for Mohs surgery.

Many teledermatology studies that exist in the literature have been conducted on both skin lesions and rashes, which makes isolating the outcomes for skin lesions alone more challenging. These combined studies have demonstrated modest to good concordance in simple percent agreement and Cohen's kappa statistic between in-person evaluation and teledermatology [21–25]. Overall, store-and-forward teledermatology may be better suited for skin lesions. There are many studies in the literature that examine store-and-forward teledermatology solely for skin lesions, which will be the focus of the next section.

Store-and-Forward Teledermatology for Skin Lesions

Studies evaluating store-and-forward teledermatology for skin lesions are extremely varied in design, making it difficult to draw direct comparisons. Many utilize simple percent agreement as an indicator of agreement between teledermatology and in-person dermatology. Traditional face-to-face evaluation is often used as the "gold standard" when histopathology is not available. However, Cohen's kappa (κ) measure can correct for agreement based on chance, for which simple percent agreement does not adjust. In general, $\kappa \leq 0.2$ indicates poor concordance, κ of 0.21–0.4 indicates fair concordance, κ of 0.41–0.6 indicates good concordance, κ of 0.61–0.8 indicates very good concordance, and $\kappa \geq 0.81$ indicates excellent or nearly perfect concordance [26]. Studies that utilize Cohen's kappa are considered more statistically accurate.

Outcomes are varied for store-and-forward teledermatology for skin lesions; most studies examine diagnostic accuracy and concordance, with fewer studies including management concordance. A systematic review demonstrated that clinic dermatology was 11% better than teledermatology via pooled comparison for primary diagnostic accuracy, but that kappa values still ranged from fair to excellent (κ = 0.39–0.98) between teledermatology and face-to-face evaluation [27].

In a study of over 3000 skin neoplasms, agreement between teledermatology and in-person evaluation varied from fair to very good for primary diagnosis (κ = 0.32–0.62) [28]. Agreement further improved for aggregate diagnoses (κ = 0.77–0.90) [28]. Teledermatologists were including similar differential diagnoses, even when the primary diagnosis did not match with the clinical dermatologist. For management, which included over ten categories, agreement was fair (κ = 0.28–0.41), which may be lower simply due to the high number of management options available [28]. This study also found that agreement rates were higher for pigmented lesions, further improving with dermoscopy [28].

A 14-year review of over 40,000 teleconsults in the United Kingdom (of which over 75% were skin lesions) was published in 2019. For the 90% of conditions that were diagnosed via teledermatology, there was 68% diagnostic concordance [29]. Most commonly, the lesions included were benign nevi, seborrheic keratoses, and basal cell carcinomas. In this 14-year period, over 16,000 face-to-face visits could have been avoided through teledermatology (1163 visits per year) [29]. Although retrospective and studied within a universal healthcare system, this study provides a significant amount of information about the real-world utilization of store-and-forward teledermatology with a large dataset and underscores real-world challenges. In the authors' practice, these challenges most commonly include photograph quality and technological problems.

A large-scale retrospective study from 2020 in Brazil compared diagnostic accuracy for teledermatology to in-person evaluation with histopathology by evaluating ICD-10 codes for skin neoplasms referred by teledermatology for in-person evaluation [30]. The authors found good concordance for teledermatology when compared to histopathologic diagnosis (κ = 0.59) and in-person evaluation (κ = 0.58) [30]. Interestingly, the category with the worst agreement between dermatologists' diagnoses was melanoma, possibly because teledermatologists were over-diagnosing out of fear of missing a melanoma that required biopsy [30]. Teledermatology reviewers more often recommend biopsies than clinic dermatologists [31], possibly because they have a lower threshold to refer for in-person evaluation when less confident about a diagnosis based on a limited photograph.

Moreno-Ramirez et al. studied over 2000 teleconsultations for skin lesions concerning malignancy. There was excellent concordance between teledermatology and face-to-face evaluation (κ = 0.81) and excellent interobserver agreement between teledermatologists for diagnosis (κ = 0.85) and referral for face-to-face evaluation (κ = 0.83) [32]. The teledermatology referral process reduced the average time of a clinical appointment by almost 2 months [32]. Teledermatology may be an accurate way to triage concerning lesions.

Clarke et al. found good concordance for primary diagnosis between teledermatology and in-person dermatology evaluation (κ = 0.60) [31]. The decision to biopsy a lesion was the primary outcome measure, which also demonstrated good concordance (κ = 0.51). Within this study, teledermatologists failed to identify 2 out of 37 skin cancers; however, over 94% of skin cancers in this study were still diagnosed correctly [31].

A 2017 study compared both store-and-forward teledermatology and live video conferencing with in-person evaluation. Diagnostic agreement for the top one and two diagnoses for store-and-forward teledermatology was 76% and 85%, respectively [33]. There were similar levels of agreement for higher resolution uncompressed and lower resolution compressed video [33]. Importantly, this study also included rashes and utilized trainees as reviewers, which could introduce bias.

Decision to biopsy is arguably the most important diagnostic determination for skin lesions, but few studies have examined this outcome. Warshaw et al. demonstrated studies with a referral-based management plan had 75% concordance, and studies examining a biopsy-based management plan had 98% concordance between clinic dermatologists and teledermatologists [27]. Clarke et al. determined that there was good concordance between teledermatologists and dermatologists regarding biopsy decisions (κ = 0.51). Another small study examined the agreement between teledermatology and in-person evaluation for decision to biopsy and found that there was 100% agreement between the two, though limited by sample size and image quality [34].

One study specifically utilized a mobile phone application for skin cancer diagnosis in over 700 patients during the COVID-19 pandemic, triaging malignancies based on urgency [35]. Results demonstrated good agreement for both primary and aggregate diagnosis for malignant lesions ($\kappa = 0.647$ and $\kappa = 0.644$, respectively) [35]. For total lesions, agreement and Cohen's kappa were equally high ($\kappa = 0.769$ for primary; $\kappa = 0.754$ for aggregate) [35].

Pigmented Versus Non-Pigmented Lesions

There is conflicting evidence in the literature about teledermatology for pigmented versus non-pigmented lesions (alternatively divided into melanocytic and non-melanocytic lesions). Arguably, pigmented lesions are some of the most important lesions to assess given the risk of melanoma. There is also disagreement about whether teledermoscopy enhances diagnosis of pigmented or melanocytic lesions, though most studies favor that it does [36]. Teledermoscopy is discussed further in Chap. 18.

One study examining only non-pigmented skin lesions found that the diagnostic accuracy for teledermatology was inferior to in-person dermatology for benign and malignant non-pigmented lesions [37]. Interestingly, the accuracy of management plans for in-person evaluation versus teledermatology did not differ [37]. A recent review article concluded that more evidence regarding the use of teledermatology for non-pigmented lesions is required before conclusions can be drawn [36].

Most studies that isolate one lesion type focus on pigmented lesions, likely due to the morbidity and mortality associated with melanoma. Moreno-Ramirez et al. found store-and-forward teleconsultation for pigmented lesions demonstrated very good concordance when compared to histological diagnosis for lesions biopsied ($\kappa = 0.79$) [38]. Agreement between different dermatologists on diagnosis and binary referral decision was excellent ($\kappa = 0.91$ and $\kappa = 0.92$, respectively) [38]. Clarke et al., demonstrated that agreement in decision to biopsy did not differ when melanocytic lesions were excluded ($\kappa = 0.51$ versus $\kappa = 0.54$), suggesting similar agreement in management for melanocytic and non-melanocytic lesions [31]. Warshaw et al. concluded that teledermatology with macroscopic images (even with teledermoscopy) was less accurate for diagnosis when compared to face-to-face evaluation but equally accurate when the authors examined management plans [39]. The study raised concerns about teledermatology for malignant pigmented lesions, given that 7 of 36 melanomas would have been mismanaged by teledermatology (defined as deviation from the gold standard of care) [39]. However, in-person dermatologists likely also miss subtle melanomas in daily practice as well, though this has not been easily measured in the literature.

In a small study of only biopsied melanomas, 74% of melanomas were correctly diagnosed and 93% were correctly managed by store-and-forward teledermatology [40]. Even in cases with incorrect diagnosis or management, the authors concluded that there were no significant consequences for patient care, suggesting teledermatology was equivalent to in-person assessment for melanoma diagnosis and management [40]. Another study utilizing teledermoscopy demonstrated that teledermatologists' management plans (monitoring versus excision) had excellent concordance ($\kappa > 0.9$) and they accurately identified all nine melanomas [41]. An additional study including teledermoscopy demonstrated that melanomas could be successfully teletriaged in less time than standard face-to-face visits (9 versus 26.5 days) [42].

Clearly, evidence is mixed regarding pigmented lesions, including whether the addition of teledermoscopy improves diagnostic accuracy. Given the concern about accuracy of pigmented lesions, one review article concluded that dermatologists should consider excluding pigmented lesions entirely from teledermatology [43]. Many of these conclusions are due to concern of the medicolegal implications of missed melanomas, which could increase morbidity and mortality for patients and litigation for physicians.

One concern about store-and-forward teledermatology in the primary care setting is the inability of the consulting physician to accurately identify lesions concerning melanoma thereby excluding them in photographs and leading to missed cancers. This pitfall was elucidated by Gendreau et al., who demonstrated that PCPs at the VA did not photograph 13 of 69 melanomas in over 12,000 consults, leading to a frequency of 10 per 10,000 consultations for "unimaged" melanomas [44]. Unless a melanoma was serendipitously caught in the periphery of another photo, this could lead to delays in diagnosis or unidentified melanomas.

Missed Skin Cancers

Many studies have noted that teledermatology evaluation alone would have led to missed skin cancers, including melanomas [31, 39, 45, 46]. Whited et al. concluded that, while teledermatology was equivalent to in-person evaluation for several types of benign lesions, the accuracy of clinic dermatology for diagnosis and management of pre-malignant and malignant lesions (including non-melanoma skin cancers (NMSC) and melanoma) was superior to teledermatology [47]. Although this data suggests there may be limitations for malignant skin neoplasms, in a more recent study, teledermatology was found to have a high sensitivity (92%) in diagnosing NMSC [48]. This high sensitivity suggests that teledermatology is a good screening tool for NMSC and that physicians may be able to triage appropriate patients directly to surgical dermatologists [48]. An additional study demonstrated similar detection rates for melanoma and NMSC in both teledermatology and face-to-face cohorts [49]. Finnane et al. concluded in their systematic review that face-to-face dermatology has a higher accuracy (67–85% agreement, $\kappa = 0.90$) than teledermatology (51–85% agreement, $\kappa = 0.41–0.63$) for skin cancers, and that methodological limitations restrict the ability to draw conclusions [50].

Asynchronous teledermatology is limited in that it is not able to pick up any incidental skin malignancies excluded from images. This was the concern specifically elucidated by Gendreau et al., as imaging in this study was dependent on the ability of PCPs to correctly identify concerning lesions [44]. Another study at the VA raised this concern for patients with an extensive skin cancer history, suggesting these patients are better examined in-person, as face-to-face examination allows for screening of incidental malignant lesions [51]. However, access to in-person dermatology visits remains challenging, often with wait times of several months. Evidence supports that over half of melanomas are actually found during full-body skin screening exams performed by dermatologists rather than based on a patient's initial reason for a visit [52]. Although asynchronous teledermatology is not intended to be a substitute for the full body skin exam performed routinely by dermatologists, it can be utilized to evaluate lesions of concern faster when a timely in-person visit is not feasible.

As with any diagnostic or treatment modality, the risks and benefits of teledermatology must be reviewed with patients. We recommend including the possibility of missed or misdiagnosed skin malignancy in this mutual decision-making process. Knowing the risk of missed malignancies, teledermatologists should also have a lower threshold to refer for in-person evaluation whenever a diagnosis is uncertain.

Fitzpatrick Skin Type

Few studies have examined the use of store-and-forward teledermatology for all Fitzpatrick skin types. One study found that agreement between teledermatologists regarding diagnosis, testing, and treatment options was not statistically different based on Fitzpatrick skin type [53]. However, this study did not utilize histopathological diagnoses as a gold standard. Many studies are unable to study this simply due to power limitations in the study design. More studies examining skin types are required to achieve better equity in the treatment of patients with skin of color.

Store-and-Forward Teledermatology with Mobile Phones

Most studies in the literature have evaluated teledermatology with traditional cameras, especially prior to advancements in mobile phones. One study utilized mobile phone photographs of skin lesions and rashes in hospitalized patients and demonstrated that there was 27% partial and 54% total agreement between store-and-forward cases and in-person evaluation [54]. Another study demonstrated excellent concordance between face-to-face and mobile phone store-and-forward dermatology diagnosis for rashes and non-pigmented lesions ($\kappa = 0.91$) [24]. Finally, Lamel et al. examined 86 patients with 137 skin lesions and determined that there was good agreement between teledermatology and in-person evaluation for primary diagnosis ($\kappa = 0.62$) and management ($\kappa = 0.57$) [55]. As mobile phone technology continues to improve, it will likely supersede the use of cameras.

Teledermoscopy

In traditional face-to-face evaluation, dermoscopy is an important tool, especially for melanocytic lesions. Dermoscopy can allow clinicians to see important vessel and pigment patterns that suggest lesions are malignant. Intuitively, inclusion of teledermoscopy could help dermatologists distinguish concerning lesions. Several studies support this hypothesis and demonstrate that teledermoscopy can improve accuracy compared to teledermatology images alone [18, 28, 56]. A systematic review concluded that accuracy rates could be increased by 15% with the addition of teledermoscopy [27]. Teledermoscopy is discussed in more detail in Chap. 18.

Image Quality

Image quality is an important factor in the success of teledermatology evaluation, especially for store-and-forward teledermatology, where evaluation is so highly dependent on the clinical image [57]. One study demonstrated that agreement increased significantly when poor-quality store-and-forward images were excluded [22]. Another study showed there was an association between confidence level of teledermatologists and the perceived image quality [28]. Of note, studies vary in the inclusion or exclusion of images of poor quality, which can potentially change concordance. Although images in many studies are taken by trained medical personnel, there is a small study that suggests patients' self-photographs generally achieve adequate image quality every three out of four times [58]. Jiang et al. demonstrated 62% of patient-submitted images were rated sufficient quality [59]. If implementing teledermatology within one's own practice, the authors recommend training the healthcare staff taking photographs to ensure there are adequate, high-quality images for teleconsults. The American Telemedicine Association (ATA) has published guidelines on best practices for digital images [60]. Implementation and practice guidelines are further addressed in Chaps. 8 and 10.

Live Video Conferencing

Live video conferencing teledermatology is a form of synchronous teledermatology that uses video to transmit information in real-time between a patient and dermatologist. Live video may not be as well-suited as store-and-forward teledermatology to evaluate skin lesions given the resolution of video is lower than still photographs. Many articles about live video teledermatology combine evaluation of both skin lesions and rashes.

In a recent review, the accuracy of teledermatology was lower than face-to-face dermatology ($\kappa = 0.41$–0.63 versus $\kappa = 0.90$), but still adequate with high-resolution video [61]. Two studies demonstrated that real-time teledermatology has similar outcomes regarding number of follow-up appointments required when compared to in-person evaluation [62, 63]. Loane et al. found that patients evaluated by store-and-forward teledermatology necessitated more follow-up appointments than those evaluated by live video conferencing (69% versus 45%), but did not isolate skin lesions alone [63].

Live video conferencing can also be combined with store-and-forward methods to maximize diagnostic accuracy, which is known as hybrid teledermatology. When real-time teledermatology was used as an adjunct to store-and-forward teledermatology, the diagnostic accuracy of dermatologists participating in the study increased by 6–14% [64]. Live video conferencing also increased patient satisfaction when combined with photograph review [64].

A 2020 study from the VA reviewed hundreds of face-to-face visits, live video conferencing, and store-and-forward encounters. Authors noted that most video conferencing visits involved inflammatory conditions, while most store-and-forward cases involved skin lesions [65]. Subsequently, there were more medication recommendations for video visits compared to more biopsy referrals for store-and-forward cases [65]. The authors concluded that live video conferencing was more beneficial for inflammatory disorders due to the ability to take a thorough history and to provide direct management over video, while high-quality photographs may be better for diagnosing neoplasms [65]. Another study comparing live video versus in-person evaluation of skin neoplasms found that there was 59% agreement between the two modalities [66].

There are few studies examining the effect of the camera quality on live video conferencing teledermatology. However, an early study suggested that camera quality is of importance in this modality, similar to store-and-forward teledermatology [67]. Given that video quality could impact the accuracy of real-time teledermatology, features such as video compression, resolution, and connection speed should be considered. The authors recommend referencing the ATA practice guidelines for specific recommendations [60].

Unfortunately, data is lacking for real-time teledermatology for skin lesions alone, as most studies have examined lesions and rashes together. However, real-time teledermatology may be a useful adjunct to store-and-forward evaluation for skin lesions. The authors have found this to be particularly beneficial in their practice when direct patient communication and education are essential.

Long-Term Outcomes of Teledermatology

There are few studies that examine long-term outcomes and long-term effects of teledermatology. Most studies have not examined outcomes past 1 year. Whited et al. studied the clinical course of patients evaluated by teledermatology compared to in-person visits over 9 months [68]. The authors found no significant differences in clinical course between patients managed with teledermatology compared to clinical evaluation [68]. Another study examined the effect of store-and-forward teledermatology on patient quality of life using the Skindex score and found no significant difference at three or nine months between traditional consultation and teledermatology [69].

An important variable to study is the long-term impact of teledermatology on melanoma outcomes. Ferrandiz et al. examined patients with primary cutaneous melanoma who were managed by teledermatology versus conventional consultation. The teledermatology group had a lower mean Breslow thickness (1.06 versus 1.64 mm, $p = 0.03$) and a higher likelihood of a more favorable initial prognosis (odds ratio of 1.96) when compared to the non-teledermatology group, possibly due to reduced time to specialist evaluation and earlier treatment [70]. More studies are required to better understand long-term patient outcomes.

Patient and Physician Satisfaction

Important outcomes for all teledermatology workflows are patient, PCP, and dermatologist satisfaction. Creating methods of teledermatology that are easy and effective to use for all stakeholders will ensure that this technology succeeds. Overall, multiple studies already demonstrate high satisfaction from patients, PCPs, and dermatologists [71–80], which is further discussed in Chap. 21.

Conclusion

Overall, teledermatology appears to have good diagnostic and management concordance when compared to traditional face-to-face evaluation. The addition of teledermoscopy may be helpful, especially for the evaluation of pigmented or melanocytic lesions. The risk of missed skin cancers demonstrated in many studies should be weighed against the benefit of reduction in delays in care when discussing the risks and benefits of teledermatology with patients. Consistently, teledermatology has expedited care while having high patient satisfaction. Additionally, diagnostic accuracy will likely improve as imaging technology improves and as care standardization increases. To improve the use of teledermatology, researchers must continue to better characterize its reliability and utility.

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Conflict of Interest None.

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11 Teledermatology: Inflammatory Skin Diseases

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The COVID-19 pandemic has required dermatologists to adapt to electronic methods of care delivery. Within months of the pandemic, virtual visits encompassed over 90% of visit types, and inflammatory skin diseases were no exception to this general trend [1]. As the United States has shifted back to primarily face-to-face (FTF) care delivery, establishing data on the efficacy and safety of electronic care delivery for specific diseases is critical. Although there are many inflammatory skin diseases that may be managed virtually or asynchronously, this chapter will focus most closely on psoriasis, acne, atopic dermatitis, and new rash evaluations—four common diagnoses ubiquitous in the dermatologic community and generally consistent with the most common diseases diagnosed and managed through teledermatology (TD) [2]. The depth of research was highly influenced by diagnosis type, with Table 11.1 illustrating the breakdown included in this chapter. Nearly half of the 53 articles in this chapter broadly covered inflammatory disease, while others specific to acne, psoriasis, rash, and eczema had varied representation in the literature. Most articles included measured general management, diagnostic capabilities, and outcomes, with limited information on demographic and access data.

Table 11.1 Breakdown of research studies included in this chapter. Of note, there were fewer studies assessing eczema and rash in teledermatology compared to psoriasis and acne

Diagnosis type	Number of articles, *n* (%)
General inflammatory[a]	25 (47.1)
Rash	5 (9.4)
Psoriasis	7 (13.2)
Acne	12 (22.6)
Eczema	4 (7.5)
Total	**53**

[a] General inflammatory was considered in all studies composed of majority or completely inflammatory dermatologic disease that encompassed multiple inflammatory diagnoses (e.g., acne, eczema, and psoriasis evaluated in a single study)

Although research is progressing, with the largest review to date published in 2022 [3], one of the greatest limiting factors for TD of inflammatory dermatoses is physician assessment of efficacy [4–6]. One study revealed that only 27% of dermatologists thought telehealth consultations were equal to FTF in terms of efficacy, and 37% of dermatologists rated their experience with inflammatory skin diseases as poor or very poor [5]. Another study revealed 87% of dermatology faculty believed skin disease worsened due to the transition to TD, although this value may be skewed by the inclusion of skin cancer

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and lack of exposure to newer, improved methods of synchronous and asynchronous TD [6]. Physicians rated rosacea, acne, eczema, and psoriasis as preferred diseases for TD management [6]. Interestingly, patients tend to show lower expectations of TD, including being 20 times more likely to report a higher quality of video and 50 times more likely to value the quality of the care they received compared to the opinion of the dermatologists [6].

Demographics and Access

The growth of virtual dermatologic services enhanced access for inflammatory skin conditions before and during the COVID-19 pandemic [1, 6–10]. Multiple studies have demonstrated that evaluations of new rashes make up 60–66% of established TD programs [7, 11]. Generally, patients that utilized TD were younger, more often non-white, with higher rates of governmental insurance and greater linguistic and ethnic diversity compared to routine ambulatory visits [7, 10, 12]. Another study, however, indicated that in a pre-pandemic cohort of pediatric patients with high rates of inflammatory skin conditions, patients that accessed TD had a lower composition of African American and Medicaid patients, with worse video quality noted during these specific encounters [13]. The difference in data between these studies may relate to the former model being asynchronous of still-images acquired in the office setting vs. home video visits requiring reliable Internet access and updated smart devices in the latter setting.

Teledermatology is expected to increase access for rural and isolated communities [8]. In the Faroe Islands, an underserved geographical location, psoriasis was the most common reason a patient sought telehealth care [8], while among US Medicaid enrollees, psoriasis was more often managed FTF than diagnoses like acne or viral exanthem [12]. Among patients with chronic plaque psoriasis during the COVID-19 pandemic, 48% preferred telemedicine for their scheduled visits [14]. A stronger preference for virtual care was associated with younger age, stable disease, and previous use of technology [14].

Acne was more likely to be managed using teledermatology compared to psoriasis and skin neoplasms among Medicaid patients [12], with high rates of referral to TD among adults relative to other skin diseases [15, 16]. A Brazilian study of over 2400 TD acne encounters demonstrated that patients were more commonly female (68%) with grade II acne [17]. Notably, 86% of these patients had never previously been treated for acne, indicating TD may be a reliable avenue to initiate dermatologic care [17]. Thirty-two percent of FTF visits in another study demonstrated inflammatory acne compared to only 14% of patients accessing TD [18]. Unfortunately, some studies have also showed 40% of caretakers of pediatric patients could not afford telehealth copays, and lack of reimbursements for these services may have perpetuated some healthcare disparities [19, 20]. Additionally, early in the pandemic, non-English speaking and older patients were more likely to have audio-only visits, which may have impacted the quality of care [21]. Even with these limitations, the majority (54%) of acne patients chose virtual follow-up, even with an FTF option [22].

Atopic dermatitis is the most common skin condition in pediatric teledermatology [23] and is common in adult teledermatology as well [16, 23]. Many studies posited that expanding telehealth services to medically underserved and resource-limited areas could benefit a great number of patients by reducing the need for FTF evaluation (Fig. 11.1) [24, 25]. One-large scale study on atopic dermatitis in telemedicine revealed that eczema represented 1648 (5.3%) of their 30,976 TD patient database, the sixth most common dermatosis [26]. Regarding utilization, a pediatric study composed largely of eczema patients revealed e-consults reduced the need for FTF dermatology evaluation in 54% of cases and reduced follow-up evaluation time by 2.5 weeks [13].

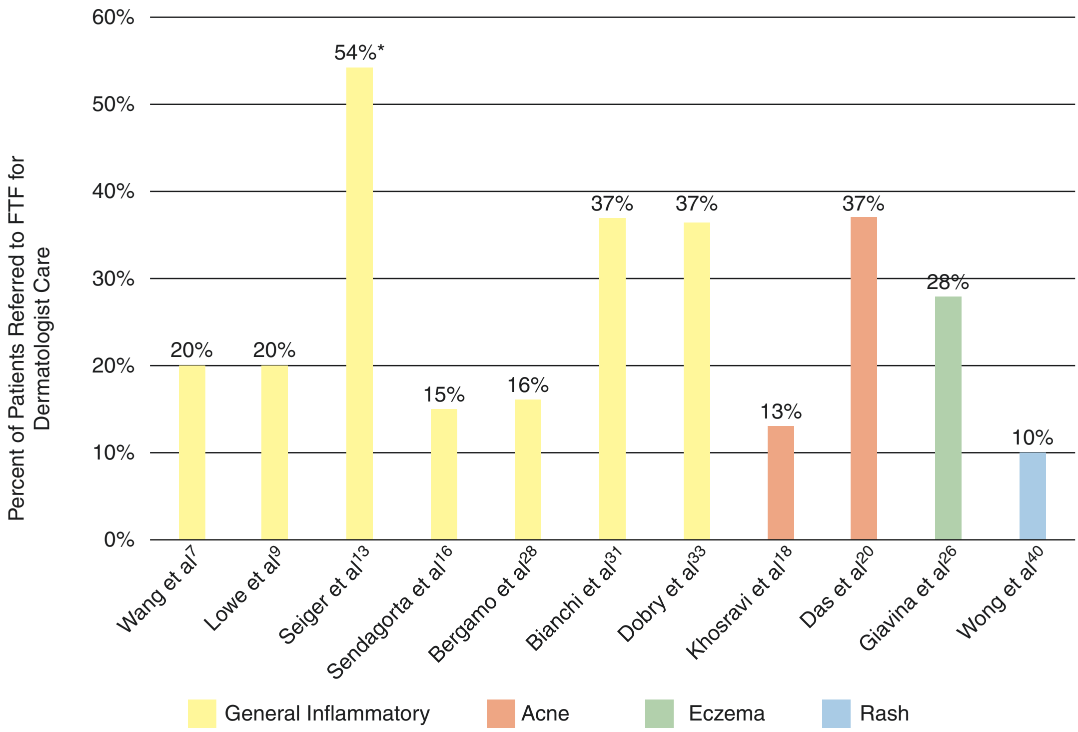

Fig. 11.1 Percent of patients referred to face-to-face dermatologist visit after teledermatologist assessment. FTF visits were significantly reduced across all studies regardless of diagnosis type. *FTF visit rate was 54% within 3 months of TD visit, but only 32% of patients were recommended FTF at the time of TD consult. This may represent acute worsening of disease or discord between teledermatologist advice and patient preference

Evaluation and Management

The data regarding diagnostic and management capabilities of teledermatology for inflammatory skin disease is mixed. Although dermatologists may believe that quality of care is reduced under TD [6], studies show that TD evaluation of inflammatory skin disease is efficacious for triage and basic diagnosis in most situations [2, 7, 9, 13, 16, 27–31]. Notably, inflammatory skin conditions like acne, eczema, and rash were more amenable to TD management compared to lesions concerning cancer [27, 28, 32]. Overall, teledermatology was shown to reduce wait times for specialty evaluation, producing quicker turnaround time and a smaller financial burden for patients [7, 9, 13, 30], but this varies based on insurance and medical plans, as it is not universally covered, and patients have voiced concerns over non-covered copays [19, 20]. Additionally, some inflammatory conditions required multiple TD evaluations to reach a diagnosis, including bullous pemphigoid and hidradenitis suppurativa [8].

Diagnostic concordance between teledermatologists and primary care providers (PCPs) and FTF dermatologists is generally high [2, 9, 29], with only a few dissenting publications [11]. Primary diagnosis between teledermatologists and PCPs was accurate in over 82% of cases in one cohort, with even greater rates in those rated as high-quality clinical images [29]. Another large study revealed 80% of inflammatory cases presenting to TD could return to their PCP with only enhanced guidance on treatment [9]. Diseases such as acne, eczema, vitiligo, psoriasis, telogen effluvium, and alopecia areata had >90% concordance rates, contact dermatitis, androgenetic alopecia, chloasma, rosacea, nail disorders, and urticaria had 70–89% concordance [2]. A large pediatric study showed that teledermatologists accurately expanded on the PCP referral, such as changing "rash/nonspecific skin eruption" to more specific diagnoses [30].

With the high diagnostic agreement, the need for face-to-face visits was greatly diminished. The rate of FTF follow-up across studies was between 13% and 54% [7, 9, 13, 16, 28, 31, 33]. Many studies did not isolate inflammatory cases from other causes of referral, which could skew the FTF referral rates, especially in cases of pigmented lesions. Ultimately, only three studies differentiated inflammatory skin disease from other causes of referral [9, 28, 31]. These studies showed that patients with inflammatory conditions like eczema, acne, seborrheic dermatitis, and pityriasis alba were referred to FTF dermatologist much less frequently than other diagnoses like vitiligo or alopecia areata and experienced wait times 7 weeks shorter following FTF referral compared to traditional referral [9, 28, 31].

In an opinion survey, all physicians believed psoriasis could be managed entirely with telemedicine or with a hybrid model (Fig. 11.2) [6]. In practice, this held true. One Italian study revealed that only 2.7% of patients required in-person follow-up [34]. Additionally, Psoriasis Area and Severity Index (PASI) scores and other psoriasis grading systems between teledermatologists and FTF dermatologists indicated TD may reliably monitor patients on systemic treatment and confer concordant management decision based on severity [35–37]. Overall, it appears psoriasis can be monitored without the need for consistent FTF evaluation in a select group of stable patients.

Utilization of teledermatology for acne management varied (Fig. 11.3) [13, 23, 31]. Although acne was among the top-three indications for referral to TD in some studies, especially among adolescents [13, 31], another study of TD referrals from PCPs revealed minimal (2.6%) acne referral rates [30]. This may strongly depend on the PCP comfort with acne treatment. Teledermatologists felt more comfortable managing acne compared to other conditions, with over 30% of physicians believing a fully virtual model to be adequate for management [2, 4, 6, 32]. In practice, interrater reliability of acne severity grading and inflammatory acne counts using multiple acne grading systems was consistently high among various TD raters and between TD and FTF raters [38, 39]. Among a cohort of referred cases, 99% of diagnoses were confirmed by FTF evaluation [18]. With regards to manage-

Fig. 11.2 A patient with psoriasis diagnosed through asynchronous consultation. Having a standardized template of questions for patients where psoriasis is suspected is useful to determine whether a patient can be treated topically with primary care, or whether are features that suggest a need for FTF management, e.g., arthritis, widespread locations, previous systemic treatments used, nail and/or genital involvement

Fig. 11.3 Acne in a young adult diagnosed and managed through asynchronous electronic consultation. The use of electronic consults in this setting ensures that patients who are ultimately seen FTF have failed adequate step-therapy and will be ready to be prepared to start isotretinoin at the time of FTF evaluation

Fig. 11.4 A patient with hand eczema diagnosed through asynchronous electronic consultation. Requesting multiple images for patients with eczema, and in general requesting both images of the hands and feet as a pair is useful for differential diagnosis and determining the severity for patient management. Additional questions including occupation and hobbies are important for hand complaints to assess the risk for allergic contact dermatitis and the need for FTF management

ment, TD more often administered oral antibiotics and spironolactone even with fewer cases of inflammatory acne, potentially indicating more severe disease [18]. Isotretinoin therapy was also amenable to TD management, with consistent cumulative doses achieved relative to FTF and conversion to in-person management only in the minority of cases [20]. Overall, TD is well suited for acne evaluation and management, including inflammatory types.

Telemedicine has also shown success in the care for eczema (Fig. 11.4) [6, 24]. Notably, a retrospective study of 1648 patients with eczema revealed 72% could be strictly managed by PCP with TD support [26]. Patients who were referred to a FTF dermatologist had their diagnosis confirmed in 84.4% of cases [26].

Nearly 80% of polled dermatologists endorsed the ability of TD to diagnose or manage new rash evaluations [6]. Nonetheless, teledermatologists often evaluated new rashes, with "nonspecific skin eruption" the top reason for FTF referral in one study [30], and others showing that 75–80% did not need in-person specialist evaluation [7, 40]. Treatment changes were made in 66% of rashes compared to 22% for other lesions [40]. Teledermatology as a hospital transfer tool was useful in decreasing unnecessary transfers for epidermal necrolysis evaluations [41]. However, TD may be inappropriate in the assessment of inflammatory conditions like HS that require a sensitive in-person physical exam with palpation, or that induce patient discomfort when displaying intimate regions, as patients often have privacy, comfortability, and data security concerns [42–44].

Outcomes

Teledermatology was a safe and effective method to assess and manage multiple chronic inflammatory skin conditions [3, 27]. One study showed 97% of TD patients were able to avoid office visits for worsening of severe chronic inflammatory diseases when current FTF therapy was withdrawn [34]. Teledermatology has also been shown to successfully alter diagnosis in nearly 70% of patients referred from PCP, particularly in inflammatory skin disease [45]. In this same study, the number of TD visits was associated with clinical improvement and change in medical management [45]. Patient and physician satisfaction is an important outcome measure, with one study showing high rates of patient and PCP satisfaction with a medical photography referral system to TD [9]. Additionally, many patients reported saving at least one hour of time compared with regular visits, and these patients had reduced no-show rates and greatly diminished time to follow-up [6, 7]. Of note, patients had faster turnaround to FTF referral than traditional consults [7, 13] and the biopsy rate was more than double compared with standard referral [33]. As referenced in the introduction, even when negative views are held by physicians and faculty, patients were noted to hold much higher opinions of the TD interaction [6].

Long-term psoriasis TD management had equivalent improvement in PASI and body surface area (BSA) scores compared to FTF care [46], without worsening over the year of TD management [47]. Patients with moderate to severe plaque psoriasis on biologic therapy showed high satisfaction with TD monitoring using mobile phone images and this TD system adequately detected adverse events including fatigue, cough, and fever [36]. Similarly, quality of life improvements among adults assigned to either 1 year of combined TD vs FTF care were equivalent [48].

Acne inflammatory lesion count was not shown to differ between patients receiving TD vs FTF care, and both patients and dermatologists demonstrated similar treatment satisfaction [49]. Parents of patients on isotretinoin therapy expressed interest in continued TD therapy and felt comfortable with both the safety and price [19]. Satisfaction was also high among adult patients, as one study demonstrated greater than 70% satisfaction with their treatment, well-being, and the attention and time provided by their teledermatologist [50, 51]. This was consistent with other studies showing high-satisfaction with web-based management [51, 52]. Interestingly, acne patients managed with TD were less likely to follow-up within 90 days even with a shorter time to follow-up, although follow-up was low in both groups suggesting an opportunity for improvement in both FTF and TD [18].

For children with eczema, TD care coupled with access to an online information portal may lower baseline disease scores equivalently with FTF care [53], with similar findings in adults [25]. With rash, outcomes research was very sparse, but studies show TD may accurately recommend treatment changes and reduce the need for in-person management while effectively selecting patients that need further follow-up [40, 41, 44].

Conclusion

Many inflammatory conditions can be successfully diagnosed and managed through teledermatology. Although demographic information is limited, TD may allow greater racial and socioeconomic access to dermatologic care, although technology may limit synchronous TD options. Complex diseases, rare diagnoses, and infiltrative skin pathology that requires palpation often require referral to FTF visit. Although many studies evaluated the ability of TD to diagnose inflammatory conditions accurately and efficiently, there are only limited large-scale studies demonstrating equivalent outcomes across diseases. Many issues remain with diagnostic, treatment, and reimbursement equivalency, but there is a broad base of evidence supporting the use and further expansion of TD in inflammatory skin disease.

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Conflict of Interest None.

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12 Inpatient Teledermatology: A Review

Joseph Mocharnuk, Trevor Lockard, Corey Georgesen, and Joseph C English III

Introduction

Inpatient dermatology is demonstrated to have a significant impact on the care of hospitalized patients with dermatologic conditions and cutaneous manifestations of systemic disease; nonetheless, it remains an underutilized resource in the face of growing demand for hospital-based expertise regarding the recognition and management of skin disorders [1]. A 2014 study aimed at assessing the national burden of adult inpatient dermatology patients reviewed 644,320 hospitalizations primarily related to skin disease, which cost the healthcare system over $5 billion. Furthermore, skin disease is diagnosed in 1 in 8 hospitalized adults, suggesting a significant need for dermatologic expertise at the frontlines of medical care [2]. Meanwhile, hospital discharge rates for dermatology-specific conditions have been increasing on the order of ~3% annually in recent years [3].

To help address this need, the Society of Dermatology Hospitalists designated the role of the dermatology hospitalist in 2009 [4]. As of 2017, their membership roster included 145 individuals, and inpatient dermatology has gradually emerged as its own distinct subspecialty [5]. Meanwhile, there has been a proliferation of studies highlighting the value of their services to both patients and healthcare systems in alleviating the burden (and associated costs) of skin disease [6].

Despite the growing ranks of trained hospitalist dermatologists, their numbers are still insufficient to meet the burden of inpatient skin disease at the 6090 hospitals in the United States [7]. Only 40% of general dermatologists reported performing inpatient consults, and 14% spent less than 1 h a week in active hospital consultations in 2009 [8]. Furthermore, most dermatologists remain geographically concentrated in urban areas, and a majority of those who perform inpatient consults are employed at academic medical centers. The urban/rural practice divide among dermatologists is further exacerbated by market forces driving younger trainees to practice in metropolitan areas with great procedural and elective cosmetic demands, though the exact breakdown of general, medical, and cosmetic

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dermatologists in urban vs. rural locales is difficult to ascertain [9]. This trend puts rural hospitals (whose access to community dermatologists is already significantly limited) at greater risk of shortages in inpatient dermatologic care [10–14].

Inpatient Teledermatology (IPTD)

In light of these challenges and limitations, teledermatology has emerged as a powerful tool in the armamentarium of the inpatient dermatologist. Several studies have demonstrated the use of teledermatology as a triage tool to assist academic dermatology hospitalist with managing their inpatient services [11, 15, 16]. Because most studies are conducted at tertiary centers, some authors caveat that their findings on the efficacy of ITPD may not be generalizable to community hospitals [17]. Though seen mostly as a triage mechanism still requiring in-person visits [18], studies have noted full inpatient teledermatology consultation is also effective for urban and rural areas with no access to dermatologic specialist [19].

As outlined in a 2014 paper, if IPTD is to be fully adopted in hospitals across the United States, its potential to improve care efficiency, cost-effectiveness, and access must be validated [20]. Therefore, the primary purpose of this review is to investigate the current literature on IPTD with a particular focus on the utility of store-and-forward teledermatology (SAFT) for diagnosis and management of skin disease as compared to face-to-face consultation. Given that most teledermatology research focuses on outpatient settings, extrapolation of SAFT research to inpatient settings may be indicated and is noted where necessary.

IPTD: Background

Inpatient teledermatology, a burgeoning field with a small but growing body of literature (only 27 articles available on Pub Med at the beginning of 2022) on its history and clinical uses, was developed to address the inpatient burden of skin disease and to improve hospitalized patients' access to dermatologic care. Though teledermatology is still considered underutilized, 55% of physician members of the Society for Dermatology Hospitalists report using teledermatology for both inpatient and outpatient consultations, with approximately 65% of respondents stating that they thought inpatient teledermatology could be best used to triage consults before assessing patients in person [10]. However, most inpatient dermatologists work at academic institutions in major urban settings, creating a significant gap in dermatologic care for some populations, especially those served by rural hospitals [13]. While the promise of IPTD has yet to be fully realized, IPTD with SAFT offers a viable means for ameliorating healthcare access inequities [19, 21]. Concerns about the diminished efficacy of IPTD relative to face-to-face visits for the diagnosis and management of skin disease are largely unfounded, with several survey studies demonstrating consistent patient and provider satisfaction with outpatient and inpatient teledermatology consultation [21, 22].

IPTD: Covid

Beginning in the Spring of 2020, the COVID-19 pandemic accelerated widespread adoption of teledermatology as hospitals sought to minimize viral transmission from in-person visits [23]. Many services considered to be nonessential were either discontinued or adapted to a virtual format, and previously underutilized electronic medical record applications for virtual and electronic visits quickly gained traction with providers [23]. Some hospitals in the United States as well as internationally (e.g., Singapore, Saudi Arabia) transitioned their dermatology visits to virtual encounters through teledermatology platforms [16, 22–26]. This switch was largely successful, with one study recognizing that the transition helped preserve scarce personal protective equipment (PPE) in the early months of the pandemic and spurred providers to work more efficiently and collaboratively [24]. Teledermatology has become an essential, established tool for the outpatient and inpatient dermatologist during the current pandemic environment and beyond [27].

IPTD: Mechanism of Action

There are two primary forms of teledermatology practice: real-time videoconferencing (synchronous) and store-and-forward teledermatology (SAFT). Some dermatologists have also used hybrid teledermatology, a combination of these two approaches. SAFT is a form of asynchronous medicine consisting of a digital image upload by a non-dermatologist practitioner for later analysis and interpretation by a dermatologist. Overall, SAFT is the more popular of the two teledermatology approaches [28]. Its dominance in outpatient settings is attributable to lower cost, greater flexibility in the coordination of care (i.e., the patient, primary provider, and consulting dermatologist need not be available at the same time), and its capitalization on advances in digital technology, including near-ubiquitous cell phone usage, improvements in and ease of digital photography, and widespread access to the Internet, allowing for seamless uploading of high-resolution images of skin disease [29]. These benefits extend to inpatient teledermatology practice, as well.

For maximum effectiveness of SAFT care, it is recommended that the dermatologist providing diagnostic and treatment recommendations also follow-up through phone conversation with the referring hospital provider and consultation notes appended to the patient's electronic medical record [17]. In previous studies, SAFT has been shown to not only decrease time to diagnosis and treatment but also to reduce the number of unwarranted clinic-based follow-up visits without compromising the quality of care and while also improving patient access to outpatient and IPTD [24, 30, 31].

IPTD: Accuracy

While teledermatology is comparably accurate to live dermatologic care in the outpatient setting, diagnostic and management accuracy is perhaps even more critical in inpatient settings, where patients are often treated for emergent and potentially life-threatening conditions [11]. Though live, in-person evaluation remains the gold standard for dermatologic care [18, 32], teledermatology can play an important and sometimes vital role. However, several factors can hinder accurate teledermatologic care, including technology failures, poor photographic technique, and missing patient history, all of which may contribute to diagnostic and management discrepancies between teledermatologists and their live dermatologist counterparts [33]. Some studies have questioned the accuracy of teledermatology on the grounds that it may miss crucial details when a patient's skin is incompletely or improperly photographed (i.e., incidental melanoma) [34, 35]. Though these concerns are worth considering, others have found that store-and-forward inpatient teledermatology using only smartphone cameras is comparable to face-to-face care, and in one illustrative example, staff members at the Singapore General Hospital who did not have any formal photographic training were able to achieve an 89.2% diagnostic concordance between inpatient SAFT and live dermatologic examination [26, 35]. Even where teledermatologic consultations are not perfectly accurate, they are substantially better than if patients were to receive no dermatology consultation at all, as supported by the frequent diagnostic and management substitution and accretion when patients are referred to the care of dermatologists after first being evaluated by non-dermatology physicians [36, 37]. Patients with complex medical dermatologic conditions and severe adverse cutaneous reactions can receive appropriate diagnostic, therapeutic management, and appropriate triage (i.e., Burn Unit) from IPTD without a live interaction [19, 38–41]. Live consultative dermatologists agree more frequently with inpatient teledermatologists than they do with hospitalists, and multiple studies have demonstrated that teledermatology concurs with the gold standard diagnosis and treatment of face-to-face dermatology between 81%–88% of the time [15, 17, 35].

IPTD: Effectiveness

In addition to being an accurate means of patient evaluation, teledermatology is also demonstrably effective in inpatient settings, and, as previously mentioned, is of significant value in rural areas with no access to dermatologic care [13]. Several studies have illustrated a high degree of diagnostic, evaluative, and management concordance of various skin conditions (e.g., psoriasis, atopic dermatitis, etc.) between teledermatology and in-person consultation, while others have illustrated that teledermatology may be equally, if not more, effective in the management of certain skin diseases [42].

A recent prospective cohort analysis of 27 dermatology hospitalists at large, urban tertiary care centers exhibited a high degree of interrater reliability between in-person and teledermatology assessment in terms of differential diagnosis, laboratory evaluation decisions, imaging decisions, and treatment, albeit with a lower degree of agreement in biopsy decisions and follow-up planning [16].

IPTD: Cost-Effectiveness

Teledermatology holds significant promise for cost reduction. A systematic review of 11 studies yielded nine that found store-and-forward teledermatology to be more cost-effective than face-to-face dermatology consultation and two which found it to be equivalent to the cost of face-to-face consultations [29]. However, savings per patient ranged from $2.39 to $261 and mostly stemmed from regained time and increased productivity rather than through a direct reduction in the cost of care [30, 43, 44]. Given this data, institutional practices and policies will play a key role in determining how cost-effective the implementation of SAFT can be. While more specific research is needed regarding inpatient SAFT's impact on hospital costs, inpatient dermatology has been shown to decrease discharge by 2.64 days and to decrease readmissions by tenfold [36]. One study illustrated that inpatient dermatology evaluation for presumed cellulitis decreased patients' hospital stay by an average of 2.1 days and estimated that such reductions could save the US healthcare system $210 million annually [45]. Another noted early inpatient dermatology intervention can reduce cost by decreasing antibiotic use [46]. These can be extrapolated to ITPD but studies are lacking. However, Georgesen et al. [19] did demonstrate antibiotic misuse occurred in 76% of inpatients initially thought to have cellulitis (no monetary savings discussed) and that the use of inpatient teledermatology consulted for SJS/TEN saved $32,000 by avoiding unnecessary ambulance transfer to academic burn centers due to incorrect hospital team diagnosis [41].

IPTD: Efficiency

Aside from its potential to improve access to care, teledermatology can also make for more efficient diagnosis and management of skin disease. A retrospective analysis comparing 11,586 patients at Zuckerberg San Francisco General Hospital divided into two cohorts, those admitted prior to the implementation of teledermatology services and those admitted after the implementation of teledermatology, saw significant decreases in patient waiting times, increases in total cases evaluated per month, and increases in the number of cases evaluated per dermatologist-hour with the introduction of teledermatology [47]. Additionally, after implementation of teledermatology services, 61.8% of consults were managed without a clinic visit [47]. Similarly, a prospective study from 2014 highlighted the potential use of teledermatology as a triage tool to bifurcate cases into nonurgent cases versus emergent cases requiring immediate in-person consultation [15]. This analysis noted substantial concordance in the decision of in-person dermatologists and teledermatologists to biopsy skin lesions. Furthermore, teledermatologists were able to triage 60% of consultations to be seen the next day or later, and on average were able to triage 10% of patients to be seen as outpatients after discharge. These studies effectively demonstrate the capacity for teledermatology to streamline patient access by at least improving clinical workflow efficiency [15].

IPTD: Quality

The accuracy of IPTD has already been established, but its quality beyond diagnostic utility should also be considered. In 2017, the American Telemedicine Association (ATA) published teledermatology guidelines to ensure quality service and patient care [48]. The ATA recommends HIPAA-compliant information security, sufficient technological specifications, and proper photographic techniques in addition to a thorough patient history for optimal use and results [48]. In practice, these guidelines have been effective in quality assurance, as surveys of patients, providers, and consulting teledermatologists have revealed consistently high satisfaction with inpatient teledermatology [21, 22].

To ensure quality inpatient teledermatology care, adequate training for both referring staff and the dermatologist consultant is needed. Just 47% of US dermatology residencies include training in teledermatology, and despite the lack of available training for young physicians, older dermatologists are often even less comfortable than residents when managing patients via teledermatology [49, 50]. Though quality standards for teledermatology have been implemented, additional telemedicine training for physicians will enable further improvements.

IPTD: Outcomes

Inpatient dermatolology has shown to improve outcomes for inpatients admitted for cellulitis [45, 46, 51].

An important and glaring finding was that cellulitis was misdiagnosed ranging from 30 to 74% of the time. IPTD had identified misdiagnosis in 89.3% of 103 presumed cellulitis referrals [19]. A similarly high rate of misdiagnosis among non-dermatologist referring providers (Table 12.1) as compared to both inpatient dermatology and IPTD consultation has been seen in conditions including SJS/TEN, Leg Ulcers, Erythroderma, Vasculitis, and VZV. Both live consulting dermatologists and teledermatologists have demonstrated improved inpatient care simply by making the correct diagnosis (as demonstrated by improved patient outcomes). Thus, the lack of dermatologic education among non-dermatology healthcare providers should be of concern to our specialty, especially in hospitalists employed at community hospitals who seem to have less diagnostic acumen and experience than their urban, academic hospitalist counterparts.

IPTD: Other Uses

Beyond direct clinical use, store-and-forward teledermatology is also well suited to clinical education. An analysis of internists providing patient care in a Midwestern hospital demonstrates the need for education and training of internal medicine physicians in the identification of dermatologic conditions [38]. Programs, such as those at UPMC Mercy Hospital in Pittsburgh, Pennsylvania, are pioneering education of internists through expert teledermatologist consultation via UPMC's teledermatology platform [39]. Among resident dermatologists, teledermatology as a teaching tool can provide significant educational benefit, as diagnostic concordance between dermatology residents and attendings was found to be fully concordant only 53% of the time [40]. For many residency programs, teledermatology is a required component of the curriculum; however, the ACGME has not codified this as a requirement for all training institutions [57]. Both dermatology residents and medical students agree that teledermatology education benefits their medical knowledge, diagnostic capabilities, and confidence in patient management. However, they report a much lower satisfaction rate with its utility in improving professionalism and interpersonal communication [58]. Inpatient telederma-

Table 12.1 Outcomes of inpatient teledermatology versus dermatologist hospitalist (live) evaluation for various skin conditions

Condition	% Cases in which inpatient teledermatologist changed diagnosis from primary care team	% Cases in which dermatology hospitalist changed diagnosis from primary care team
Cellulitis/abscess	89.3% [19]	30–74% [5, 45, 46, 51]
SJS/TEN	97% [41]	71.6% [55]
Leg ulcers	86.4% [52]	45% [56]
Erythroderma	78.8% [53]	*No data available
Vasculitis	89% [54]	33% (includes vasculopathy) [5]
VZV	82% [54]	42% (includes other viral exanthemas) [5]
Immunobullous disease (i.e., pemphigus vulgaris and bullous pemphigoid)	84.9% [54]	100% [17]

tology as an educational tool is therefore best suited for the development and reinforcement of clinical knowledge in combination with other educational modalities.

IPTD: Advantages and Disadvantages

As summarized in Table 12.2, teledermatology has unique advantages and disadvantages. Because it does not require the patient and provider to be physically present or concurrently available, teledermatology provides faster and more cost-effective care [19, 41]. It increases access to dermatologic expertise for hospitals without or with dermatologic hospitalists and, as previously mentioned, can be useful for patient triage [11, 15, 19, 20, 59]. Real hospital cases can effectively be used for education of dermatology residents and even the referring primary care team [39, 58]. Furthermore, in circumstances such as the current pandemic, where physical face-to-face exposure carries inherent risk, teledermatology is a safe, effective alternative to in-person consultation.

On the contrary, teledermatology requires access to secure technology capable of capturing and transmitting high-quality photographs. Additionally, in cases where patient history is sparse or in which physical palpation would significantly aid diagnosis, teledermatology may be a suboptimal approach [34, 58]. For some complex patient populations, prior face-to-face experience seems to be required to conduct a remote evaluation in a high-quality manner, including full-body skin exams, so as not to miss potentially life-altering diagnoses [34, 60]. Reimbursement for teledermatologic consultation is currently insufficient to incentivize care [61]. Additionally, states vary in whether they allow a physician licensed in another state to practice without additional certification. To improve interstate care, states have passed legislation to join membership as part of the Interstate Medical Licensure Compact, which currently includes 29 states and Guam [62].

Table 12.2 Advantages and disadvantages of inpatient teledermatology

Advantages	Disadvantages
Faster, cost-effective care	Underutilization in part due to provider skepticism
Increased access to care especially in resource-limited areas	Requires access to good-quality technology
Useful for patient triage prior to admission or before transfer	Possible limited patient history and no palpation or physical exam maneuvers
Shorter hospital stays and lower odds of readmission	May miss incidental lesions if no full-body exam is done
Cases can later be used for education	Reimbursement is at best poor
No risk of disease exposure of or to the patient	State licensure requirements vary and may prevent interstate consultations

IPTD Reimbursement

Recently approved Current Procedural Terminology (CPT) codes for electronic (SAFT or asynchronous) consultations have laid the groundwork for more widespread use [63]. These codes include 99,451 for when the provider, a consultant, spends five or more minutes evaluating a patient's medical condition via various electronic media and prepares a written report for the referring provider; 99,452, for when the provider, a treating or requesting physician or other qualified healthcare professionals, spends 30 min providing healthcare information about a patient to a consultant via various electronic media; and 99,446, for when a consulting physician performs a 5–10-min consult via telephone, Internet, or electronic health record (EHR) and provides a verbal and written report to the requesting physician/qualified healthcare provider (addenda are 99,447 for 11–20 min consult, 99,448 for 21–30 min, and 99,449 for 31 or more). The new CPT codes 99,451–99,452 and 99,446–99,449 have payment ranges from about $18 to about $73 dollars depending on the time involved. Interprofessional services provided under these codes can only be billed by qualified Medicare practitioners, and the patient's verbal consent must be noted in the patient's medical record given that these services will be performed when the beneficiary is not present, and cost-sharing will apply [61, 64]. These codes can be used for outpatient and inpatient e-Consults. Neither 99,451/2 nor 99,446/9 accounts for billing differences based on the degree of medical decision-making, and codes 99,451/2 also fail to account for differing amounts of time spent by the provider. Reimbursement for the most complex code, 99449, is roughly on par with that of the least complex office visit [61]. In order to be compensated a more reasonable amount and to cover overhead (administrative, IT costs), UPMC developed service contracts based on hospital bed size and set fee per number of consults per month. For synchronous (virtual) teledermatology, COVID has prompted emergency use authorization for in-person office visit CPT codes 99,211–99,215 with a 95 modifier for outpatient and 99,251–99,255 with a 95 modifier for inpatient virtual or synchronous telemedicine consults. Although synchronous teledermatology, with reimbursement similar to in-person visits, due to its inherent inefficiency and lack of popularity prevents any gain when compared to SAFT. Representation of teledermatologists at governmental organizations (CMS) to increase the 99,451/99446 codes physician fee will be crucial for advancing inpatient teledermatology in rural and community hospitals nationwide.

Conclusion

The field of inpatient teledermatology has emerged from a growing need for dermatologic expertise in the hospital setting. While there is plenty of evidence to support the need for dermatologic care within hospitals and even for inpatient SAFT as a potential solution, there is still comparatively low adoption of this approach. IPTD is an effective, accurate, and cost-saving resource available for patients and healthcare systems alike. However, barriers to implementation remain, including the potential for misdiagnosis without full-body skin exams or due to inadequate photo quality, as well as reimbursement concerns stemming from the poor regulatory structure and limited interstate licensure opportunities. Despite these shortcomings, inpatient teledermatology is rapidly emerging as a method for improving patient outcomes in areas where access to dermatologist hospitalist care is limited. Its use and adoption are expected to continue significantly benefiting patients in the future.

Conflict of Interest None.

Financial Associations

None.

Human and Animal Rights

All reported studies/experiments with human or animal subjects performed by the authors have been previously published and complied with all applicable ethical standards (including the Helsinki declaration and its amendments, institutional/national research committee standards, and international/national/institutional guidelines).

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13 Teledermatology: Pediatric

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Abbreviations

IH	Infantile hemangioma
PCP	Primary care provider
SF	Store-and-forward

Overview

Expanding access to teledermatology in the pediatric setting has the potential to address many challenges given the mismatch between supply and demand for board-certified pediatric dermatologists. Pediatric dermatology is one of the smallest medical subspecialties in the United States and fewer than 400 board-certified pediatric dermatologists are responsible for caring for 74 million American children [1, 2].

Teledermatology often constitutes a significant value-added in the pediatric setting, given the substantial degree of disagreement between referring providers and dermatologists [3, 4]. Teledermatology can also expand access to expert consultation for patients living in remote or rural areas [5, 6]. While up to one-third of pediatric office visits nationwide may involve a skin complaint [7, 8], less than 4% of pediatric dermatologists practice in a rural setting, and seven states have no pediatric dermatologists at all [9].

Therefore, teledermatology may help reduce wait times, improve clinic attendance rates, and enable patients to consult doctors from a wider geographic area [1, 10–14]. Teledermatology can also help triage patients who truly need specialist consultation thereby reducing healthcare costs from unnecessary referrals, and reducing the need for patients to incur travel costs [15, 16]. Ancillary benefits may also include a reduction in carbon emissions from decreased travel [17].

The use of teledermatology skyrocketed during the COVID-19 pandemic, with 97% of American dermatologists reporting its use. Seventy percent of dermatologists believe that teledermatology will continue after the pandemic, and 58% of practitioners intending to use the technology even after the pandemic subsides, an increase of nearly fivefold compared to pre-pandemic rates [18].

This chapter will describe the types of teledermatology, their advantages and disadvantages, the use of teledermatology for specific diseases, as well as practical considerations for the use of teledermatology in the pediatric population.

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Diagnostic Concordance and Teledermatology

Diagnostic concordance is an important metric when discussing the utility of teledermatology. Diagnostic concordance is the measure of whether the patient receives the same diagnosis when the provider is using teledermatology compared to an in-office visit [4, 19]. Apples-to-apples analysis of diagnostic concordance is often challenging, as certain studies may compare diagnoses given by different physicians in teledermatology and in-office visits, and others may compare both diagnoses against a "diagnostic gold standard" such as histopathology. One retrospective study of 429 pediatric dermatology consultations found that full diagnostic agreement between primary care providers (PCP) and dermatologists occurred in only 48% of cases, and management recommendations were only concordant in 28% of cases [20]. The most commonly misdiagnosed conditions among PCP in this survey were tinea versicolor, seborrheic dermatitis, pityriasis rosea, xerosis, and lichen striatus [20]. In general, diagnostic concordance in pediatric teledermatology ranges from 55% to 82%, which appears to be lower than the concordance rate in adult teledermatology based on the limited number of studies conducted on this topic [4, 16, 19–22].

The most common pediatric teledermatology diagnoses are atopic dermatitis, molluscum, acne, verrucae, benign melanocytic nevi, and acne [4, 19, 20]. When comparing diagnoses given by the same dermatologist in both teledermatology and in-office visits, studies indicate that diagnostic concordance is highest for inflammatory dermatoses and rashes [23], as well as birthmarks such as hemangiomas [24] (Table 13.1). In contrast, alopecic disorders have been associated with a higher degree of discordance between in-office and teledermatology consultation [24, 25]. The use of standardized templates for history-taking, as well as training in high-quality photography can improve diagnostic concordance [21]. While teledermoscopy may improve concordance for pigmented lesions and nail lesions [3], a still-substantial degree of discordance indicates that teledermoscopy is best used as a triage tool to risk-stratify the lesions which need subsequent in-office evaluation [1, 14]. Diagnostic concordance varies regarding pigmented lesions, as methodologies have not been consistent across studies. For example, one review of 144 cases by Jolliffe et al. showed that among melanocytic lesions evaluated initially via telemedicine consult, none of the lesions found to be malignant on histopathology were misdiagnosed as benign during the initial encounter. However, the initial consult included video imaging and improved lighting, which may not be available in standard telemedicine encounters [26].

Pediatric teledermatology consultations may be effective for complex genodermatoses, as this may facilitate conversations between patients with rare conditions and specialists who are located in geographically distant centers [27]. In these situations, specialists may also use teledermatology to hold joint consultations with multiple patients who share a rare disorder [6], and thus create a supportive and educational community.

Table 13.1 Diagnostic concordance with the same provider in teledermatology and in-office consultation

Diagnosis	Perfect diagnostic concordance rate between teledermatology and in-office consultation with the same dermatologist (%)
Birthmark (hemangioma)[a]	100 [24]
Nail disorders	77 [3]
Inflammatory dermatoses or rashes	76–92 [23, 24]
Infestations and infections	75 [23]
Hair disorders	64 [24]
Tumors and nodules	67–79 [23, 24]
All diagnoses	82–83 [20, 23, 24]

[a]Denotes <10 patients evaluated

Finally, teledermatology may be useful in triage of certain common conditions such as acne, mollusca, atopic dermatitis, and other non-urgent conditions that may not need an in-office visit [4]. One retrospective study from Brazil found that 63% of lesions in primary care settings could be managed with store-and-forward pediatric teledermatology consultation and only 1% of cases required biopsy [28]. However, this study was limited by a lack of a control group therefore precluding discussion about diagnostic accuracy.

Types of Teledermatology

Teledermatology platforms can be categorized into three major groups: live-interactive, store-and-forward, and hybrid [29]. Live-interactive (LI) teledermatology, also known as synchronous teledermatology, refers to live videoconferencing that occurs between the physician and the patient and/or caregivers. Store-and-forward (SF) teledermatology, also known as asynchronous teledermatology, occurs when clinical information and photographs of patients are collected in a specific digital platform, and is later reviewed by a consulting physician at a separate time. Hybrid models incorporate elements of both LI and SF teledermatology, for example, consulting dermatologists may request to review clinical photos while directly videoconferencing with the patient in order to improve diagnostic accuracy [30]. In a survey of dermatologists during the COVID-19 pandemic, 94% of physicians reported using LI teledermatology (the most common modality), although 72% of physicians perceived that the hybrid model had the greatest diagnostic accuracy [31].

A review of the advantages and disadvantages of each type of teledermatology was described by Cartron et al. [1], and is further summarized in Table 13.2.

Table 13.2 Summary of the advantages and disadvantages of various categories of teledermatology platforms

Type	Advantages	Disadvantages
Live-interactive	• Live interaction, closest simulation to in-office visit • Simplest to understand • Increased rapport between patient, family, and provider • Can have multiple individuals on the same call • Can visualize patient home environment • Real-time physical examination • Ability to interpret manipulated lesions if proper guidance provided	• Poor image quality or connectivity limits effectiveness • Limited child-directed care • Impractical for different time zones
Store-and-forward	• Ability to review clinical data and consult with other providers without time pressure of a live appointment • Diagnostic accuracy if there are high-quality images in store-and-forward platform • No fixed time, more convenient to schedule • Easy to communicate across time zones	• No live interaction • Inability for patient to ask questions directly can cause inefficiency • Clinical images may be poor quality
Hybrid	• Advantages of both live video interaction with simultaneous review of photos and other clinical data	• Can be confusing for both physicians and patients to use both video and photo upload services • Can be cost-prohibitive in certain systems due to complexity of technology involved

Family-Centered Care

Family-centered care is defined as "an approach to healthcare that is respectful of and responsive to individual patient preferences, needs, and values, and ensures that patient values guide all clinical decisions" [32, 33]. Such an approach is vital for any doctor-patient interaction however takes on added importance in pediatrics, given that parents, guardians, and other caregivers are frequently involved. Skin concerns in the pediatric population may be especially harmful to the quality of life and result in significant psychosocial morbidity, as well as thoughts of self-harm [34]. Similarly, caregivers of patients with severe skin disorders also frequently report feelings of chronic helplessness, as well as exhaustion and sleep disturbances [35, 36].

Providing family-centered care can be especially challenging via teledermatology. Prior to initiation of teledermatology, careful discussion with the patient and their family should occur whenever possible in order to set expectations and to determine the optimal method of consultation. Such discussions are critical in situations with multiple primary caregivers (as in the case of divorced parents who share custody) who may have differing approaches to communication with their child and their child's physician [37, 38].

Live-interactive teledermatology may be the best method of providing family-centered care, as live interaction allows the patient and their family opportunities to ask questions and to build rapport with the clinician. Virtual encounters also provide insight into the patient's home environment, and potential barriers to care [1]. Some videoconferencing portals also allow multiple individuals to participate simultaneously thus providing a solution for separated parents who both desire to join the health visit for their child. However, parents may also find live videoconferencing inconvenient if they live in different time zones from the physician, or if they have young children who are uncooperative with the live examination. While a typical office visit may involve child-friendly toys or distraction tools, these are nearly impossible to implement over a video encounter. Store-and-forward or hybrid platforms can be alternatives as long as patients and families are comfortable with sending high-quality images through SF platforms.

Store-and-forward teledermatology has become an increasingly common method of pediatric dermatology consultation, and both patients and providers report satisfaction with its use [39]. Through ease of storage and dissemination of high-quality images, SF can be used effectively for many common pediatric disorders [4].

Socioeconomic Barriers To Access

It is worth mentioning that all types of teledermatology presuppose access to technologies that may be out of reach for many patient populations [40]. The Federal Communications Commission estimates that as of January 2021, nearly 27 million Americans lack Internet connection [41, 42]. Although this number has steadily declined over the past few decades, approximately one-third of rural residents and nearly 35% of lower income households with school-age children lack broadband connection [41, 42]. Rural and lower income households are precisely the populations that might benefit from the promise of expanded healthcare access via teledermatology. In addition, patients and families with language barriers, or certain disabilities involving hearing or speech may be unable to access teledermatology [43].

Teledermatology: Specific Conditions

There are certain common conditions in Pediatric Dermatology that have been evaluated specifically in regards to teledermatology. A discussion on the use of teledermatology for some specific conditions is provided below.

Acne Vulgaris

Acne vulgaris is one of the most common chief complaints encountered in dermatology, especially in the pediatric population [44, 45]. Acne may be one of the skin conditions most conducive to management via teledermatology, given that facial lesions can often be visualized easily through videoconferencing or high-quality images, and treatment often proceeds in an algorithmic manner [44, 46]. Diagnostic concordance is high, and dermatologists can typically identify acne subtypes solely based on clinical images and adjust therapies accordingly [47]. One Brazilian study of 2459 patients found that the use of teledermatology can effectively classify acne subtype and severity, as well as acne sequelae including post-inflammatory hyperpigmentation and scars [48]. In this study, more than two-thirds of acne patients could be successfully managed with teledermatology alone, without the need for an in-office consultation. Those who were referred for in-person consultation were disproportionately male, as male patients tended to have more severe acne at baseline. Many patients had waited over 3 years for the teledermatology consult due to the lack of available dermatologists, and 86% had never received any prior acne treatments. Therefore, teledermatology has the potential for large cost savings as well as reducing the strain on the healthcare system by triaging nonurgent visits [48].

Patients are generally receptive to this approach. In an Italian survey, over 92% of patients who received acne treatment via teledermatology during the COVID-19 pandemic reported high levels of satisfaction with their care, and 90% stated that they would continue to receive care from the same dermatologist [44]. A retrospective study of 505 acne patients between March and May 2020 in New York found that patients who lived further away from dermatology clinics were more likely to choose teledermatology. Even after COVID-19 restrictions were lifted, teledermatology accounted for approximately half of all acne follow-up visits, and the majority of follow-up visits for systemic agents such as isotretinoin and spironolactone [49].

Teledermatology can indeed help in the management of systemic agents, such as oral antibiotics, spironolactone, and isotretinoin, given the need for frequent appointments and lab monitoring, especially in the latter [50]. A study of acne 400 follow-up appointments in Pittsburgh showed that time to follow-up was significantly reduced among teledermatology visits compared to in-office visits (median 45.5 days in teledermatology group vs. 64 days for in-office group). Teledermatology patients were much less likely to attend follow-up appointments (13% follow-up rate in teledermatology vs. 31% for in-office visit); inconsistency in follow-up appointments was a challenge in both groups, demonstrating the need for greater availability of dermatologic care overall. This study also found that teledermatology patients were more likely to be prescribed oral antibiotics (43% vs 28.5%) or oral contraceptives (18.5% vs. 12.5%) compared to in-office patients, indicating that monitoring of systemic complications can be performed safely in the teledermatology setting.

Live-interactive teledermatology is generally preferred from both patient and provider perspectives, as both parties can comment on progression of therapy, monitor for side effects, and titrate doses as needed [51, 52]. In Austria, a randomized controlled trial which allocated patients to either teledermatology or in-office monitoring of isotretinoin found comparable clinical outcomes [51]. Teledermatology monitoring of isotretinoin may be especially beneficial for members of the military or their dependents, as they face unique barriers to follow-up and must frequently relocate, which can jeopardize their ability to receive continuity of care [53]. Strategies for optimal management for military members or dependents include starting with the highest possible dose that can be tolerated in order to achieve a higher cumulative dose more quickly and to potentially prevent relapses [53]. Some studies have posited a target dose of 1.6 mg/kg daily in order to expedite treatment courses by up to 2 months [54].

In the United States, compliance with the iPledge™ isotretinoin monitoring program provides unique challenges [55]. During the COVID-19 pandemic, iPledge™ allowed patients to submit photographs of negative at-home pregnancy testing in lieu of in-office testing. This change likely improved access to patients who were unable to attend in-office appointments however there have been reports of patients submitting photos from prior months and otherwise using telehealth to circumvent monitoring guidelines [56]. Therefore, any use of teledermatology with isotretinoin and iPledge™ must occur with thorough quality assurance to ensure compliance with guidelines [57].

Atopic Dermatitis

Atopic dermatitis is one of the most common dermatologic diagnoses in the world, and a frequent reason for pediatric dermatology consultation [58]. Diagnosing atopic dermatitis or its variants such as nummular eczema can be challenging even for experienced practitioners, and teledermatology can assist PCPs in obtaining rapid consultation in order to expedite the diagnostic process [28]. Teledermatology can also help level the playing field in underserved communities and provide expanded dermatologic access to these patients [59]. Several randomized controlled trials of online healthcare compared to in-office visits in a variety of settings including medically underserved areas found comparable rates of improvement in atopic dermatitis in both groups [60–64].

For example, Armstrong et al. conducted an equivalency trial in a medically underserved area of Colorado where 156 children and adults were randomized to a direct-access, online store-and-forward teledermatology platform or to regular in-office visits for the management of atopic dermatitis. After 12 months, both groups had equivalent decreases in Patient-Oriented Eczema Measure (POEM) and Investigator Global Assessment (IGA). Overall, 38.4% of patients in the teledermatology arm achieved clearance or near-clearance of disease compared to 43.6% in the in-office arm, a difference which was not statistically significant and indicated equivalence in the efficacy of both arms [60].

In a similar study in the Netherlands focused on cost savings, 199 patients with comparable severity in eczema were randomized to either an online teledermatology portal or in-office visits. Data were collected at baseline, 3 months and 12 months, and there were no significant differences in disease-specific quality of life, severity of AD, and intensity of itching between both groups at the three time points. Additionally, the teledermatology arm showed significant cost savings in the range of €600 per patient in the first year of treatment however there was potential for further cost savings due to decreased work absenteeism and other indirect costs [62].

Remote assessment of severity in atopic dermatitis is also comparable to in-person evaluation thus allowing dermatologists to adjust management as needed for refractory cases [65]. Studies have also shown that educating various caregivers including medical assistants and community health workers about atopic dermatitis can also improve outcomes and quality of life for patients [66]. Optimizing smartphone applications that help educate providers and patient families about eczema management might also help reduce barriers to care [67]. Therefore, teledermatology may be a promising method of involving non-physician workers in the care of patients with atopic dermatitis [68].

Infantile Hemangiomas

Certain conditions such as infantile hemangiomas (IH) require more specialized monitoring due to the risk of potential complications, and thus specific guidance on the use of teledermatology is needed.

Due to the reduction of in-person appointments during the COVID-19 pandemic, the Society of Pediatric Dermatology released consensus guidelines on the management of infantile hemangiomas. While these guidelines were developed during the pandemic, they may also be applied to analogous settings in which in-person office visits are impractical or impossible.

The consensus guidelines recommend telemedicine initiation of topical or oral beta-blocker therapy for standard-risk patients, while advising in-office consultation for higher risk patients [69].

Criteria for standard risk include the following [69]:

- Adjusted gestational age > 5 weeks.
- Normal birthweight.
- Recent documented weight (within 2 weeks).
- Normal cardiovascular examination within previous 4 weeks. (including ≥1 documented HR after nursery discharge).
- Normal respiratory examination within previous 4 weeks.
- Healthy in the 24–48 h prior to the scheduled telemedicine visit (especially, no respiratory and gastrointestinal signs and symptoms).
- IH pattern and distribution do not confer the risk of PHACE or LUMBAR syndrome.
- Lack of ulceration or minimal/superficial ulceration.
- The caregiver is able to understand instructions and demonstrate comprehension (e.g., by repeating instructions provided during visit).
- Multiple IH with normal liver ultrasound and without cutaneous IH conferring risks noted in Group 2.

Criteria for higher risk include the following [69]:

- Corrected gestational age < 5 weeks.
- Abnormal cardiovascular examination or investigations OR those who lack documentation of this in the post-natal period.
- Medium-to-high risk of PHACE (i.e., large segmental facial in segments S1, S3, S4, or scalp IH).
- Medium-to-high risk of LUMBAR syndrome (i.e., segmental perineal and/or lumbosacral body IH ± visible associated anatomic abnormalities).
- Significant IH ulceration.
- Ongoing poor oral feeding or poor weight gain.
- IH with symptoms of airway compromise (e.g., stridor) or bilateral S3 (beard area IH at high risk for airway IH).
- Known pulmonary disease including ongoing respiratory compromise (e.g., dyspnea, frequent wheezing, or history of bronchospasm).
- Persistent or ongoing hypoglycemia.
- Known or suspected congenital heart disease or suggestive symptoms.
  - Known or suspected aortic coarctation.
  - History of pathologic heart murmur or abnormal echocardiogram.
  - Ongoing diaphoresis.
  - Ongoing tachypnea.
  - Ongoing tachycardia.
  - History of syncope.
- Extensive hepatic hemangiomas including those resulting in consumptive hypothyroidism or congestive heart failure.
- Known brain malformation.
- Family history in first degree relative of:
  - Congenital heart disease.
  - Sudden death or arrhythmia.
- Maternal history of connective tissue disorder (e.g., systemic lupus, Sjogren syndrome, polymyositis, or other).
- Case-by-Case Basis:
  - These guidelines assume that infants are receiving regular well-child checkups including height and weight measurements, and routine heart and lung examinations. If these examinations are not occurring regularly due to extreme healthcare disruptions, it cannot be easily determined whether patients have normal growth, normal baseline characteristics, and/or a healthy cardiopulmonary circuit. In these situations, the decision to start beta-blocker therapy should be determined on case-by-case basis.
  - If in-person visits are not possible for any reason (e.g., pandemic-related disruptions or extreme geographic barriers), then decision to start beta-blocker therapy should be made on case-by-case basis in conversation with relevant subspecialists.

The consensus guidelines advise that teledermatology visits in these settings should be live videoconferences as providers can counsel parents on treatment options, appropriate use of the medication and side effects, and to answer any questions in real time. Teledermatology visits can also be helpful alternatives in non-pandemic situations such as natural disasters or geographic isolation. The guidelines further clarify that teledermatology can be especially helpful for regular follow-up appointments in the rapid growth phase of IH, which may begin in the first few weeks of life and last until 6–8 months of age [70]. These visits can help the provider alter treatments if needed based on patient response and symptoms. Such guidance is necessary to avoid serious complications. For example, a recent case report indicates that prompt pediatric dermatology consultation may have prevented the rare complication of septic vasculitis within an infantile hemangioma [71].

Inpatient Consultations

Due to the significant demand for pediatric dermatology expertise, many physicians are asked to provide curbside consultations. While these may improve collegiality and may be educational, they are generally uncompensated, time-consuming, may harm patient confidentiality, and leave the provider at risk for medico-legal liability [72]. However, formal inpatient consultation with pediatric dermatologists may be impractical for many hospital systems, as the vast majority of the few board-certified physicians practice in urban centers and within 50 miles of the closest fellowship program [9].

Teledermatology can be a possible solution to this challenge, as a formal consultation can allow the pediatric dermatologist to assist in patient care even when not physically present at the bedside [27]. Prior to establishing a consulting service, the consulting dermatologist and the hospital system should establish guidelines as to which types of inpatient consultations are appropriate, the type of teledermatology platform (most commonly SF) as well as the expected time from consult request to consult initiation [1, 27, 73]. Such guidelines can be determined on a case-by-case basis and may vary depending on the size of the institution, the number of available pediatric dermatologists and support staff, and other institution-specific concerns. For example, one retrospective review found that the average response time after the initial consult request was 5.84 hours (range 0.07–118.13) however calls from the emergency department were usually returned within 90 minutes [74]. In contrast, a retrospective review at another institution found that although the median time from consult request to initiation was approximately 12 h, consult notes were typically completed within 7 min of completing the consult [73]. Furthermore, some hospital systems may choose to task fellows, residents, physician assistants, or nurse practitioners with answering urgent calls and escalating care as appropriate to the attending.

The main obstacle to consistent implementation of teledermatology inpatient consultations aside from the paucity of pediatric dermatologists is likely financial. Although teledermatology may produce some cost savings for hospital systems [13], physicians are often reimbursed at very low rates for both consults and teledermatology [75] thus disincentivizing physicians from offering to perform these services [1, 11]. Regulations regarding telemedicine consultation have varied significantly during the COVID-19 pandemic, with some hospital systems mandating that a physician retain a state license in the same state where their telemedicine patient also resides [76]. Changes in compensation structure, federal and state law, and hospital system policies will be required in order to further incentivize pediatric dermatologists to provide teledermatology services.

Medical Education

Teledermatology also provides unique opportunities for medical education. During the COVID-19 pandemic, many aspects of medical education including both preclinical and clinical education were shifted online [77]. While there have been reduced opportunities for medical trainees to participate in traditional clinical roles [78], the proliferation of online learning platforms has enabled both trainees and practicing physicians to connect with leading clinicians outside of their immediate geographical areas [77, 79–82].

One prominent example is Dermatology Project ECHO (Extension for Community Healthcare Outcomes). This initiative at the University of Missouri is a program designed to improve rural access to dermatology through telementoring of PCPs [83]. Each ECHO team consists of a multidisciplinary group of adult and pediatric dermatologists, dermatopathologists, clinical psychologists, and advanced practice nurses who meet weekly with PCPs and review complex dermatologic cases [83]. This team then makes management recommendations and helps educate rural providers about dermatologic conditions. A pediatric-focused teledermatology ECHO workshop was also highly effective in helping PCPs learn evaluation and management for common pediatric dermatology disorders [84]. The knowledge-sharing network produced through Dermatology Project ECHO has been shown to help in the management of unusual conditions, such as in the case of a woman who developed an atypical mycobacterial infection after being spurred by a rooster [83], as well as another case of a 19-year-old girl who was treated unsuccessfully for a variety of conditions after an appendectomy before being finally diagnosed with allergic contact dermatitis secondary to topical antibiotics [85].

Some training programs have also successfully used teledermatology to continue expanding access to indigent populations. For example, during the pandemic, several medical schools in the Boston area created a student-run pediatric teledermatology clinic focused on improving access to care among underserved patients [86]. This clinic had a relatively low non-attendance rate, likely because multilingual students were available to conduct patient outreach and reduce barriers to care [86].

Dermatology may be especially conducive to virtual learning due to the importance of visual recognition. As long as high-quality images can be obtained in a teledermatology setting, residents and medical students can continue to improve their clinical acumen [87]. A study in Pittsburgh found that both medical students and residents reported significant improvements in clinical dermatology skills after performing pediatric teledermatology consultations and receiving targeted feedback [88]. Prompt consultation and discussion among dermatologists can also help expedite diagnoses of rare pediatric conditions, such as ichthyosis, and provide educational opportunities for all physicians involved [89, 90].

Conclusion

There is significant demand for pediatric dermatology, however there are fewer than 400 board-certified providers serving over 70 million American children. Teledermatology may improve access to care for certain pediatric populations and can help patients with rare disorders communicate with specialists who are geographically distant. There are three major types of teledermatology platforms: live-interactive, store-and-forward, and hybrid. Live-interactive teledermatology allows for live videoconferencing and an environment that comes closest to an in-office examination but can be limited by time constraints and poor-quality imaging. Store-and-forward teledermatology allows providers to review data and communicate with patients at separate times thus allowing for a more comprehensive evaluation, but without live discussions. Hybrid platforms may include the strengths of both platforms but may be limited by the complexity of the technology precluding use by both patients and providers. Teledermatology can provide high diagnostic accuracy for certain types of skin complaints such as inflammatory dermatoses and can serve as a triage tool to direct certain categories of patients towards in-office visits. Teledermatology consultations may prevent life-threatening complications in specific conditions such as infantile hemangiomas. Inpatient teledermatology consultations can improve patient care by reducing the need for informal curbside consultations however there are numerous logistical and financial barriers to widespread implementation. Teledermatology can also provide innovative opportunities for integration with medical education.

Conflict of Interest None.

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Further Reading

American Academy of Dermatology. Telemedicine Resources. https://www.aad.org/public/fad/telemedicine

Society for Pediatric Dermatology. Telemedicine Resources. https://pedsderm.net/resources/teledermatology/

14 Teledermatology: Mohs Surgery

Manya Saaraswat, Fabio Stefano Frech, and Keyvan Nouri

The COVID-19 pandemic introduced many barriers to providing healthcare, especially in the field of dermatology. In fact, dermatology was one of the most affected medical specialties due to dermatologic examinations and procedures requiring close inspection, which was advised against during the pandemic [1]. Unfortunately, the pandemic not only introduced but also exaggerated many dermatologic conditions; for example, repeated hand washing and wearing personal protective equipment increased skin damage in healthcare workers [2]. Furthermore, studies showed that the SARS-CoV-2 virus had cutaneous manifestations as well, including erythematous rashes, urticaria, and chickenpox-like vesicles [3]. To overcome hurdles introduced by the COVID-19 pandemic, many dermatologists implemented teledermatology to continue to provide care.

Teledermatology uses telecommunication technologies to diagnose and treat skin diseases. Telemedicine has been available and used for some time by many medical specialties. However, it is especially useful in dermatology due to the visual nature of skin examinations [4]. Teledermatology has many applications including being used for diagnostic purposes and also for postoperative evaluations. Additionally, it allows for enhanced access to care for patients who may be disadvantaged due to location or socioeconomic status.

During the COVID-19 pandemic, the US healthcare system reallocated many resources to COVID-19 patients by delaying many dermatologic procedures including Mohs surgeries [5]. Mohs surgery—also called Mohs Micrographic Surgery (MMS)—is the most effective and preferred technique for treating many skin cancers such as basal cell carcinoma or squamous cell carcinoma (SCC) in high-risk areas. A UK-based study found that as a direct consequence of reallocation during the pandemic, almost 50% of MMS services had ceased and an additional 36% were reduced [6]. During this time, many physicians began implementing teledermatology. A study that surveyed members of the American College of Mohs Dermatology found that less than 25% of members offered telemedicine prior to the pandemic. However, during the surge, 86% were now utilizing teledermatology [7].

Mohs surgeons used teledermatology in both consultations and postsurgery management. However, although many surgeons believed that teledermatology was useful during the pandemic when they were surveyed in 2020, only half said they would employ teledermatology in their practice post-pandemic [7]. Regardless, teledermatology has been shown to be a useful tool, and

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despite some COVID-19 regulations being lifted, many dermatologists still choose to utilize telemedicine.

Dermatologists can currently employ three types of teledermatology: store-and-forward (SAF), live-interactive (LI) technology, or a hybrid form which includes asynchronous and synchronous teledermatology simultaneously [8]. SAF is asynchronous: a patient's images and information are put together and then sent to a dermatologist, who receives the package several hours or days later. On the other hand, LI teledermatology uses live video-conferencing technology so that patients are now only separated by location, but not by time as they are in SAF teledermatology [4]. Both SAF and LI have their respective advantages and disadvantages, which will be discussed in the context of Mohs surgery later in this chapter.

This chapter will outline the current uses of teledermatology within Mohs surgery. Teledermatology can be used both before Mohs surgery for preoperative consultations as well as for postoperative evaluation. This chapter will also highlight the advantages and disadvantages of teledermatology as well as the next steps and the future of telemedicine in Mohs surgery.

Teledermatology Prior to Mohs

Teledermatology can be useful prior to Mohs surgery. Studies have shown that SAF teledermatology can be effective for patient referrals in general dermatology clinics [9]. Using SAF telemedicine, a primary care physician or general practitioner can capture relevant images of their patient and send them to a specialist to confirm a diagnosis [10]. In fact, a study conducted in Spain actually showed how the use of SAF patient referrals decreases time to Mohs surgery. This study examined 134 patients who were referred to a cancer center from surrounding primary care clinics. Primary care physicians used SAF telemedicine to send dermatologists photos of a patient's skin lesions as well as the patient's general medical information. A dermatologist would review the material and return a report to the primary care physician with a diagnosis, preoperative management instructions, and a scheduled day for surgery. All preoperative tests were conducted in the primary physician's office; on the day of surgery, if there are no contraindications, the surgery is performed by the Mohs surgeon. Compared to patients who were seen and operated on without SAF teledermatology, patients with teledermatology had a much shorter waiting interval: 26 days compared to 30 days. In general, this study showed how teledermatology is useful as a preoperative tool for skin cancer; it helps avoid unnecessary visits to the hospital and decreases waiting time for surgeries [11]. Additionally, teledermatology allows surgeons to plan ahead, which can increase access to care by reducing the number of clinic visits [9].

Similarly, another study at the Bronx Veterans Affairs Medical Center also compared teleconsultation to conventional consultations for Mohs surgery. This study showed that teledermatology almost doubled the percentage of lesions treated with Mohs surgery within 60 days of the consult request. The authors also showed that teledermatology decreased time to treatment by 2 weeks and resulted in average travel savings of about 167 min for patients [12]. According to a study by Pak et al., not only does telemedicine allow patients to save time, but it also allows patients to save more money if they used SAF teledermatology compared to a conventional dermatology referral process [13]. This study, conducted in a Department of Defense setting, randomized patients to either receive a teledermatology consult or a traditional in-person consult. Cost of care was calculated by using Medicare reimbursement rates and drug prices; the cost included clinic visits, teledermatology visits, radiological tests, procedures including Mohs surgery, and loss of productivity costs. This study found that although teledermatology patients incurred higher costs originally when productivity loss cost was taken into account, SAF teledermatology is actually the cost saving strategy [13].

Other studies have confirmed that virtual consultations for Mohs surgery do not increase the number of appointments or stages needed to clear tumors compared to in-person consultations [14]. In fact, one study found that teledermatology consultations were actually associated with fewer dermatology clinic visits before Mohs surgery [15]. Although convenience is increased for both patients and physicians when utilizing virtual consultation, it is important that patient satisfaction stays constant. Fortunately, studies have already highlighted that patients feel just as informed and educated in virtual consultations as they do in traditional in-person consultations [14].

In fact, one study showed that patients preferred a virtual consultation over an in-person consultation by over 67%. This same study actually showed that physicians concurred with how effective teledermatology consultations are: over 80% surveyed in this study felt that virtual consults should continue post-pandemic [16].

Additionally, dermatopathologists can use teledermatology to assist in diagnosing SCC, BCC, and other malignancies. A study conducted at the Mohs surgery laboratory at Memorial Sloan-Kettering Cancer Center in New York compared evaluations of skin biopsies conducted between a telepathology system and an on-site dermatopathologist. The results indicated that there was complete agreement in all telepathology and conventional light microscopy diagnoses, which bears evidence that telepathology is a feasible alternative. This study highlighted that telepathology in consultations for Mohs surgery can optimize patient care, allowing for enhanced discussion of cases due to time saved [17]. If physicians integrated telepathology, it may allow for more efficient assessment especially for challenging cases.

Teledermatology Post-Mohs Surgery

Teledermatology can also be utilized after a patient undergoes Mohs surgery. In fact, the aforementioned study which surveyed members of the American College of Mohs Surgeons found that the most common use of telemedicine by Mohs surgeons during the start of the pandemic was postoperative management [7]. Although this could be due to many newly scheduled surgeries being put on hold during 2020, telemedicine still has advantages in post-procedure monitoring.

Instead of patients scheduling a postoperation clinic visit, they can utilize teledermatology. Now, electronic medical records can be viewed by the patient giving Mohs surgeons another platform to communicate with their patients. In addition, many studies are examining new ways to communicate post-Mohs surgery care to patients. One study randomized 90 MMS patients to receive postoperative information through either text messages, related videos, both text messages and videos, or just standard in-person nurse-directed wound care. The authors found that patients experienced a reduction in anxiety after watching the MMS video. Additionally, patients were more likely to report the video as "very helpful" when compared to the pamphlet given during a traditional visit. Lastly, this study found that patients actually preferred to receive wound care instructions by text messages [18]. Similarly, another study which examined patients in a dermatology practice in Michigan found that almost 75% of patients preferred video delivery of post-Mohs surgery instructions as opposed to receiving in-person instructions from the provider. Furthermore, the authors found that about 34% of the whole sample reported that they were intimidated by healthcare workers [19]; this could explain why some patients preferred the video delivery method.

Postoperative care after Mohs surgery is extremely important, and if telemedicine increases patient satisfaction and comfort, teledermatology may have the potential to be more beneficial than in-person visits. In fact, studies that have looked at other surgeries have shown that unclear postoperative care instructions can lead to increased and unnecessary utilization of health care services [20]. This is also pertinent for those undergoing MMS. Another study conducted in New Zealand and the UK showed that overall patient satisfaction was higher if they received a telephone follow-up after their Mohs surgery. Moreover, this study found that many patients would still be content if this phone call was not from their Mohs surgeon [21]. This allows for better allocation of a healthcare team's time and resources.

There have been recent innovations in teledermatology to allow for improved communications between physicians, which ultimately will improve a patient's postoperative care. For example, physicians and researchers at Loma Linda University created smart glasses that allow surgeons to take HD photos and videos without using their hands. The authors explain that these smart glasses may be especially useful for surgeons performing MMS defect repairs in the future [22]. Additionally, in this study, the physicians identified patients undergoing Mohs surgery who also had pre-scheduled ENT surgeries. The Mohs surgeons utilized the smart glasses during the surgery and then the photos and videos of the defect were sent to the head and neck surgeons intraoperatively; the authors highlight that the improved communication between physicians improved the outcomes of the surgery as well [22]. Asynchronous teledermatology can also be helpful for Mohs surgeons communicating with plastic surgeons prior to referrals. For example, in regard to free flap procedures, plastic surgeons can use smartphone applications and messaging to monitor free flap perfusion. Dermatologists may use similar technology to avoid complications post-Mohs surgeries to maximize flap or graft survival and communicate with other specialties within a patient's care team [9]. Additionally, smart glasses and similar technology can be utilized in live teleconsultations. Not only a quick consultation with other physicians useful for a difficult case, but technology like this is also helpful for educational purposes.

Challenges to Teledermatology

Teledermatology comes with its own set of challenges as well. Regarding smart glasses specifically, some physicians worry about patient privacy [23]. This concern can be extended to any images or videos captured by physicians. Stevenson et al. highlight that many times a practitioner's personal smartphone is used to capture and communicate images [24]. Furthermore, the authors highlight that if physicians do not take appropriate safety precautions (e.g., obtaining consent), there may be a legal risk for practitioners. Adhering to HIPAA requirements is especially pertinent when utilizing SAF teledermatology; for the physician to come up with a differential diagnosis, not only are photographs of the lesion sent to a dermatologist but a patient's medical information also must be included. Of course, medical identifiers (birthdate, MRN, etc.) should be excluded, but studies argue that a patient's history along with a description of the lesion could provide necessary clues to identify the individual [25]. One way to overcome this barrier is to create an internal SAF system within the EMR system that the physician already uses. Carter et al. argue that internal SAF systems have many advantages; not only does the patient feel safer because their information is more secure, but these internal systems allow for better continuity of care and improved access to clinical records [26]. The implementation of this system may help dermatologists make more accurate diagnoses, while at the same time decreasing some risks of compromising patient privacy.

Moreover, there are other legal barriers in utilizing teledermatology. Although telemedicine allows physicians to provide care in areas where they are not physically present, many states still require the physician to be licensed in the jurisdiction where the patient is located [27]. Additionally, many states also have restrictions and specific requirements for the type of technology the physician utilizes during teledermatology visits. For example, according to Goodspeed et al., Idaho does not allow for SAF teledermatology during consultations; instead establishing a physician–patient relationship must be done through synchronous telemedicine (i.e., LI teledermatology) [27].

However, SAF teledermatology is more commonly used than LI teledermatology [28]; this may be due to SAF permitting physicians to have more flexibility with their time. Yet, there are many disadvantages to SAF teledermatology as well. For instance, Garfinkel et al. stated that

SAF does a poor job at mimicking bedside diagnosis, not allowing for a proper establishment of physician–patient relationship [8]. In fact, these authors concluded that since LI teledermatology permits the provider to engage with patients and access more of a patient's clinical background, LI teledermatology should be utilized over SAF [8]. However, LI teledermatology also has many disadvantages as well, mostly including technical challenges. For example, having poor Internet access can lead to lower image quality, which may impact the accuracy of the diagnosis [8].

Additionally, a study conducted at the University of Missouri measured diagnostic confidence in both SAF and LI teledermatology; the purpose of this study was to compare these modalities with in-person diagnostic confidence [29]. The authors found that SAF and LI teledermatology were not significantly different from each other but the diagnostic confidence for both was much lower than in-person. This suggests that dermatologists were more confident in their diagnosis when the visit was conducted in-person. Although this study found that agreement in diagnosis was extremely high between both forms of teledermatology and in-person visits, the authors highlight that a physician's trust in their ability to make professional judgment is crucial to a patient's care. Therefore, dermatologists need to be confident in diagnosing lesions through telemedicine before teledermatology can be regularly used [29].

A dermatologist's lack of confidence could be due to factors outside of their control, such as technical difficulties. One study pointed out that at times teledermatology visits have inadequate lighting, which makes diagnosing lesions difficult [30]. In fact, many physicians express that much of the operational inefficiency faced in teledermatology is due to poor image quality [28].

Additionally, patients who are using LI teledermatology will need specialized guidance and instruction prior to the visit to properly display their lesions [31]. A study at the University of Mississippi Medical Center exemplified this: the authors found that about a third of patients rated "showing their skin" to their provider through the video camera as "hardest" on a given scale [32]. However, the authors noted that this challenge could be overcome by using SAF teledermatology to supplement LI teledermatology.

This tension around new technology is also shared by the provider, as introducing a new technology creates problems in a healthcare setting because it changes the way work is organized and undertaken [33]. This is especially important during a dermatology consultation or referral by a primary care provider. A study in California examined the perspectives of referring PCPs on teledermatology in the context of the California Medicaid population; an important theme they found was the need for improved workflow and communication not only between providers (i.e., the PCP and dermatologists) but also between clinic staff [34]. If a doctor's office is not working efficiently, it can decrease patient satisfaction and may result in worse outcomes.

Additionally, although teledermatology can be useful for post-Mohs surgery evaluation, some studies found that it may decrease patient satisfaction as virtual visits may not allow for the opportunity to address evolving complications [21]. This could be due to patients perceiving the virtual visit to be impersonal [35]. In fact, studies have found that even despite high satisfaction with teledermatology, many patients still prefer in-person dermatology visits [32].

Lastly, because teledermatology is a fairly new form of healthcare, reimbursement for the care is not fully fleshed out. Due to the lack of reimbursement mandates in many US states, teledermatologists may incur out-of-pocket costs to provide service [36]. Additionally, many dermatologists do not practice telemedicine because they do not fully understand the reimbursement process [36].

All aspects of teledermatology—including referrals, telepathology, post-op evaluations—face similar challenges related to physician resources, technology, patient privacy, and cost. However, for the benefits of teledermatology to be fully realized and be beneficial to patients, improvement in the sustainment of teledermatology programs need to be ensured [37].

Conclusion and Next Steps

This chapter highlighted how teledermatology may be used in the context of Mohs surgery. Additionally, although there still are barriers to utilizing telemedicine within MMS, advancements in optimizing the technology should be continued as it may comprise an essential tool in delivering dermatologic care. As previously mentioned, teledermatology allows for both decreased time to diagnosis and decreased time to Mohs surgery [15]. Additionally, some arguments against teledermatology may be refuted. Although the reimbursement process is not concrete yet, telemedicine may be more cost-effective for the provider. In fact, the cost of operating an interactive teledermatology practice may be less than that of a conventional clinic [38]. Also, although there is some lack of confidence within a physician to use new technology, studies show that future medical professionals are ready to implement teldermatology. A recent study that examined the readiness of Lebanese medical students to use teledermatology post-COVID-19 showed that over half of the students indicated they are ready to utilize teledermatology as part of their practice now and in the future [39].

Additionally, teledermatology allows for more patients to benefit from getting any concerning lesions evaluated in a timely manner. A study that examined the use of teledermatology in California found that over 75% of patients seen via teledermatology were at or below 200% federal poverty level and usually lived in rural regions without dermatologist access [28]. Teledermatology has also been useful to provide care to incarcerated patients as well [40].

Public interest in teledermatology specifically for MMS has also seemingly increased during the last few years. Analyzing google searches in an accepted way of gauging interest in certain medical procedures one study found that searches, such as "mohs surgery/surgeon + virtual/telehealth" and "skin cancer surgery + virtual/telehealth," increased during and post-COVID-19 pandemic [41]. This shows that despite the pandemic coming to an end, dermatologists may find substantial benefit in offering virtual healthcare.

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15 Teledermatology: Cosmetics

Suzan Obagi

Introduction

The use of smartphone applications to facilitate patient interactions began to take shape in the early 2000s with the utilization of these devices to triage acute trauma and burn patients. As technological platforms and camera resolutions improved, the use of smartphones to help evaluate patients in which a strong visual element is a central part of their presentation continued to grow [1]. Vyas et al. performed an extensive updated review of telemedicine in plastic surgery and dermatology from 2010 to 2016 showing the numerous ways in which telemedicine played an important role in managing a wide range of patients as the technology improved, allowing physicians to seek virtual consultations, triage patients, postoperative monitoring of flap vascularity, and to improve access to healthcare for rural patients [2]. However, the adoption of telemedicine both as asynchronous (store-and-forward) and synchronous (live-video conferencing) formats increased exponentially during the COVID-19 pandemic [3, 4].

At the start of the pandemic, telemedicine was quickly implemented to reduce the number of patients coming into the clinics and hospitals in an effort to control the spread of the coronavirus and to reduce exposure risk to the clinical staff and patients. As the spread of the virus began to wane and safer ways were found to bring patients back into the office in-person, telemedicine continued to play an important role in plastic surgery [5]. The same, if not more, would be expected in dermatology. Teledermatology in a cosmetic practice is extremely useful, as will be discussed, in triaging postoperative patients, evaluating issues arising from the use of a topical skincare regimen, planning out treatment strategies, and for certain cosmetic consultations.

Asynchronous Teledermatology

Asynchronous teledermatology plays an important role in cosmetic dermatology if utilized correctly. The save-and-forward modality can be implemented in two manners, consultation or triage. First of all, asynchronous teledermatology can be used to screen patients that are being referred for the “cosmetic” treatment of skin lesions. Rather than have the patient schedule an in-person consultation followed by an appointment to treat the lesions, one step can be eliminated by having the patient send in good quality photographs of the areas or lesions of concerns. Once the photos are evaluated, the treatment modality or modalities are then decided upon. For minor procedures, such as noninvasive lasers

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(vascular, lentigines), electrodessication (sebaceous hyperplasia, seborrheic keratosis), and cosmetic moles shaves, the patient is electronically sent a list of recommended treatments, a cost quotation, and information handouts (detailing the procedure and recovery) that pertain to each treatment they will receive. Once the patient receives all of this information, they will then call the office to schedule the appropriate treatment. We have found that even existing patients will oftentimes send in photographs of lesions that bother them so that we may schedule a treatment for them rather than having to come in for a consultation. The successful use of this modality for consultations requires that the office have the necessary patient handouts available electronically so that the entire process is seamless.

The second manner in which asynchronous teledermatology is utilized is to triage issues that arise in our cosmetic dermatology patients. Patient phone calls can be quickly converted to asynchronous messages if having a photograph is deemed helpful to figuring out what issue the patient is having. Typically, if a patient is having excessive irritation, redness, or dryness from their skincare routine a simple photograph accompanied by a list of what they are using on their skin allows for a quick triage to determine if it is simply an irritant reaction or a true allergy (swelling, hives). This process eliminates the guesswork and needs for the patient to come into the office for a minor issue that can be resolved with a few adjustments to their skincare routine. Skin resurfacing patients are another subgroup of patients that benefit from this type of communication. Typically, post-resurfacing, patients are brought back into the office for an in-person visit at days 3 and 7. However, at some point during the recovery process, patients begin to worry and want to check in to make sure that they are healing properly. Sending in high-quality photographs can quickly allow the physician to determine if everything is proceeding as expected and to identify a potential complication early. This is especially useful for patients that live a great distance from the office.

Additional ways to utilize asynchronous teledermatology is for the neuromodulator and filler patients. If a patient is concerned that their neuromodulator treatment is causing an asymmetry or ptosis photographs (at rest and with dynamic movement) are very useful to determine if an asymmetry exists or to differentiate between brow ptosis (will require a visit to balance the opposite side) or eyelid ptosis (will require a prescription for iopidine eyedrops rather than a visit to the office). Similarly, filler asymmetries or issues with post-filler edema can be triaged on photographs and the appropriate management can be determined (at-home massage versus in-office hyaluronidase injections).

For a very busy cosmetic dermatology practice, asynchronous teledermatology has been a timesaver for both the patients and the physicians.

Synchronous Teledermatology

Synchronous teledermatology in a cosmetic practice can play an important role, albeit less so than asynchronous teledermatology. During the limited in-person visits at the height of the pandemic, there was a very large demand for cosmetic consultations. It could be that patients were at home and looking for ways to improve their appearance while they could work from home or it could stem from the fact that many work meetings became virtual and patients began to see themselves on camera and did not like how they appeared [6, 7]. The convenience and safety of a virtual consultation allowed patients to set a plan into place that they could proceed with once the office was open again for elective procedures. Additionally, as with the rest of the global esthetic skincare market, the sales of medical grade skincare products direct-to-consumer increased dramatically during the shutdown [8, 9]. Patients were not traveling or spending on clothing so there was a large increase in spending on higher end skincare products.

Synchronous consultations pose a slightly different challenge than asynchronous visits. Synchronous visits require a good quality web camera (laptop, tablet, or phone), adequate lighting (ring lighting is most ideal), a way to mount the camera to keep the image steady, and enough bandwidth to allow for uninterrupted video streaming. However, there is a limit as to what can be assessed during a virtual synchronous visit. Skin resurfacing needs or the treatment of vascular and adnexal lesions is easy to assess. Acne scars can pose more of a challenge as both direct and indirect lighting is crucial to determine the scar morphology and the depth of the pathology. As for neck laxity and body adiposity, a preliminary consultation virtually can help set the stage for further discussions about surgical options such as rhytidectomy or liposuction. Usually, an in-person evaluation is still required prior to proceeding with a planned surgery. This can be scheduled as a preoperative visit in which the patient is evaluated in-person and the preoperative physical exam is performed as well at the same time. This allows for the review of the planned surgery, ordering of labs if indicated, and a physical examination to confirm that the surgery is indeed the correct procedure needed.

Optimization of the Patient Interaction Process

At the time of making the consultation appointment, patients are given a specific set of instructions to allow for a streamlined visit (Fig. 15.1). The medical assistant or nurse can admit the patient online and ask them all rele-

a

Cosmetic Consultation – Teledermatology Guide

Thank you for choosing (name of the practice). To optimize the consultation process, please carefully read all of the steps below prior to your teledermatology video visit.

Preparing for the visit

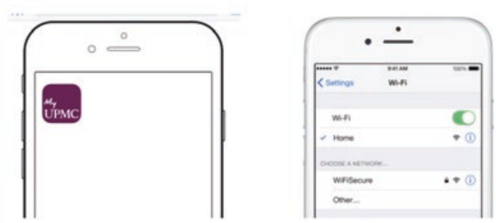
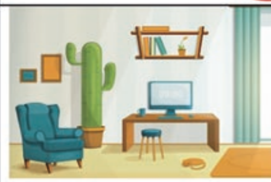
1. Please ensure the following: • Your device is fully charged (iPhone/iPad/Android) o Laptop & desktop computers will not work • myUPMC app is installed on your device and you have set it up and logged in • The internet connection on your device is functioning properly. o The (name of telederm platform) app functions best over a Wi-Fi connection. o Directions for using the video visit function in the myUPMC app are provided in a separate guide. o Test that the app properly functions in the room in which you will perform the video visit (see below).	
2. Ensure that your device's camera and microphone are properly functioning. You can test this by taking a brief 5-second video with your device.	
3. The best camera to use is the one on the back of your smartphone (rear-facing camera). For that reason, if you can have someone assist you by holding the phone during the visit, it would provide the highest resolution images, allowing for the best clinical assessment of your skin. Please ask a trusted family member or friend with whom you are comfortable sharing your visit information with if they can assist you. If you are alone, please try to use a stand to prop up or support for your smart device.	

Fig. 15.1 (**a–d**) Digital Patient Instruction Guide for Synchronous Cosmetic Consultations created by Rashek Kazi MD, PhD, Carolyn Willis MD, Suzan Obagi, MD

b

Preparing the room

1. Never perform a video visit while driving in a moving vehicle. The visit should be performed at home. The consultation visit often takes around 15-20 minutes.	
2. Please select a well-lit room, ideally one in which the walls are bare and neutral-toned in color (white, light gray, light blue). Place the seat so that the light source is in front of you. For example, do not have a window behind you, as that often results in shadows and glares. A well-lit bathroom or sitting in front of a mirror with lights is acceptable.	 
3. Have a pen and paper with you as your provider will likely provide several instructions which you may want to write down.	

Preparing your skin (about 15-30 minutes before the visit)

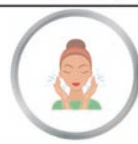
1. Cleanse your face with warm water and a gentle cleanser. Remove any makeup from your skin. Do not apply any makeup, moisturizer, or toner. This will allow your provider to have a clear picture of your skin at baseline.	
2. If you have long hair – Please tie your hair back in a *loose* ponytail. 3. Attire – Generally there are no specific requirements and you can dress casually. If you have concerns of specific body parts, please be prepared to show those areas to your provider. For example, if you want to inquire about your neck or arms, wearing a tank-top or loose t-shirt may be preferable.	

Fig. 15.1 (continued)

c

Performing the visit

1. Start the (telederm platform) app and begin your virtual visit as instructed.	
2. IF YOU HAVE SOMEONE ASSISTING YOU WITH THE VISIT: When you are in the video visit, there will be an option to switch the camera to use the backside/rear-facing camera. Select this then hand the phone to whomever is assisting you. The rear camera resolution is much better than the front ('selfie') camera.	
3. Depending on the concerns you have, the provider will ask you to provide a variety of angles from different positions. When you provide the best position, hold it for a few seconds as the provider will be putting that image directly into your chart.	Patient Photo Positions 

Fig. 15.1 (continued)

d

4. Follow your provider's instructions and complete your visit. Usually your provider will mail you information packets covering everything that was discussed. They might also send that information via the myUPMC app so that you get the information more quickly.

Consultations are provided for an assortment of cosmetic concerns. Read the information below to see if you have any of the concerns listed and then read the instructions about what images your provider will likely need during your visit. Understanding this now will be a great help for your provider and allow them to recommend the best treatment options. See the above for example photos.

Acne
Full face at rest
Left Cheek
Right Cheek
Forehead at rest
(if applicable) Upper chest, Right Shoulder, Left Shoulder, Upper Back

Wrinkles
Full face at rest
Forehead at rest, forehead with eyebrows raised, forehead scowling
Eyes at rest, eyes closed, eyes closed tightly
Mouth at rest, mouth smiling, mouth smiling with teeth shown, frowning, frowning with teeth shown
Right cheek at rest, Right cheek smiling
Left cheek at rest, Left cheek smiling
Neck at rest

Skin aging (skin blemishes, dyspigmentation, scarring, etc.)
Full face at rest
Oblique views (45°) of the right and left face

Skin Laxity, Neck Tightening
Full face and neck in 1 photo (showing forehead to collarbones)
Oblique views (45°) of the right and left face/neck (showing forehead to collarbones)
Lateral views (90°) of the right and left face/neck (showing forehead to collarbones)

Eyes
Full face (showing forehead to chin)
Full face smiling
Eyes- up close at rest
Eyes- up close smiling
Eyes- up close with eyes closed gently

Fig. 15.1 (continued)

vant questions about the patient's allergies, medications, preferred pharmacy, and fill out some of the cosmetic consultation template questions (Fig. 15.2). The physician can then log on and complete the questionnaire, evaluate the patient, and come up with a treatment plan.

Patients are instructed to log in 5–10 min early prior to the start of their appointment, avoid having make-up on their skin, sit away from bright windows, have a stand to stabilize their device, have a paper and pen ready, and follow the handout as to which photos to take and upload prior to the start of the visit.

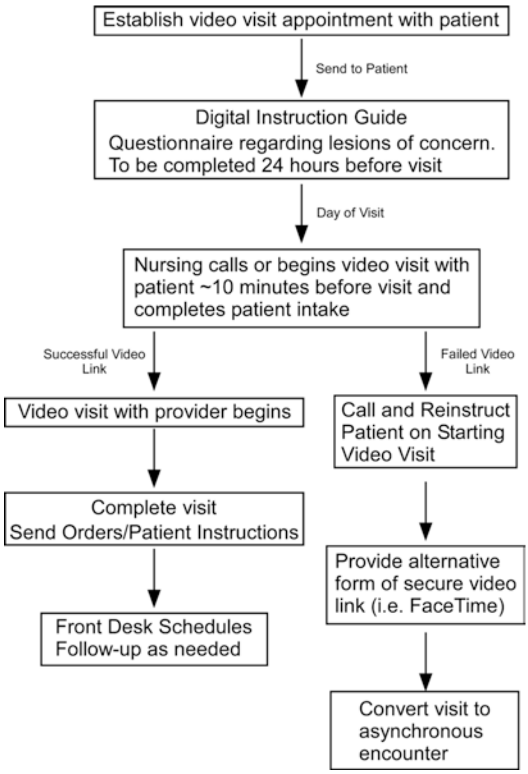


Fig. 15.2 Flowsheet of a Synchronous Virtual Consultation created by Rashek Kazi MD, PhD (UPMC Dermatology)

Conclusion

Necessity is the mother of innovation as the adage goes. While telemedicine is not new, the COVID-19 pandemic pushed this technology out much more quickly to all medical practices. Within the realm of plastic surgery and dermatology, this technology has found a new home much more than in other specialties due to the visual nature of our patient's concerns. While initially there was a learning curve among staff, providers, and patients, the platforms have improved and everyone's comfort with virtual platforms increased during the shutdown since virtual platforms were being used to socialize and to work thus not solely for medical purposes. This improved technological knowledge made patient adoption of virtual visits a little easier than it otherwise would have been. When implemented properly, teledermatology will remain an integral part of a cosmetic dermatology practice.

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Conflict of Interest None.

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16 Teledermoscopy

Shelley K. Uppal

Introduction

Over the last three decades, dermoscopy has been established as a reliable diagnostic method for the diagnosis of pigmented and nonpigmented lesions and the early detection of melanoma and nonmelanoma skin cancers [1, 2]. The advantage of dermoscopy is that it allows the clinician to visualize features that are not discernible by naked-eye examination and often reduces the need for semi-invasive or invasive procedures, such as skin scrapings or biopsy [1, 3]. Teledermoscopy is an increasingly popular subdivision of teledermatology that involves the acquisition of dermoscopic images from a remote site through digital platforms (i.e., mobile or digital teledermoscopy) to improve the remote assessment of skin lesions [4, 5]. While face-to-face (FTF) dermoscopy remains the gold standard for diagnosing pigmented lesions, direct visualization is often difficult in remote areas and settings with high patient volumes, stringent social distancing measures, or logistical barriers that prevent direct FTF assessments [4]. Teledermoscopy has emerged as a useful tool that providers can use to ameliorate barriers to FTF care and optimize care for patients in a variety of healthcare settings. This chapter will outline the digital platforms used for the teledermoscopic evaluation of skin lesions and discuss the advantages, limitations, and special considerations for teledermoscopy in the clinical setting.

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Digital Modalities and Platforms Used in Teledermoscopy

Sequential Digital Dermatoscopic Imaging (SDDI)

Mobile devices (mobile teledermoscopy) and non-mobile digital devices (digital teledermoscopy) are two modalities used for acquiring and transmitting digital dermoscopic images for the evaluation of skin lesions [5, 6]. In digital dermoscopy, digital images are often acquired and stored via digital cameras, smartphones, or tablets [5, 6]. Images acquired through mobile or digital teledermoscopy can be adapted to the clinical setting and used in sequential digital dermatoscopic imaging (SDDI), machine learning, and teledermoscopy [6]. SDDI involves sequentially capturing and assessing lesions at different time points, which allows them to be compared for subtle changes over time [6, 7]. SDDI detects melanomas that lack classical dermoscopic features by identifying relevant changes in incipient melanomas during interval follow-ups (Fig. 16.1) [8]. By comparing two images of a lesion taken at different time points, SDDI analyzes for specific dynamic criteria that infer the biological behav-

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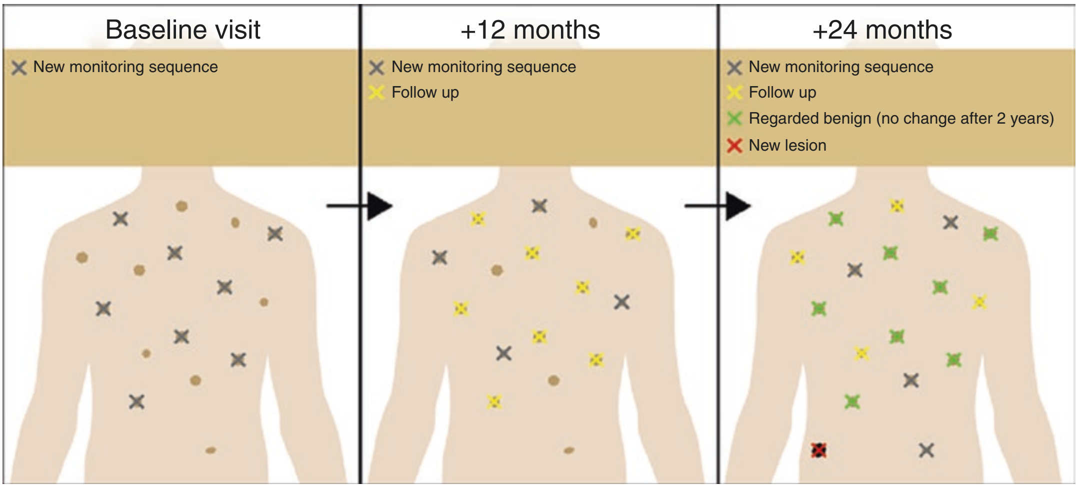

Fig. 16.1 In sequential digital dermatoscopic imaging (SDDI), lesions of interest are selected (gray) and imaged at subsequent visits (yellow). Some lesions are discarded from follow-up after showing no change for 2 years (green). Other lesions that appear at follow-up are monitored (red). Reprinted from "Sequential digital dermatoscopic imaging of patients with multiple atypical nevi" by Tschandl, 2018, *Dermatology Practical & Conceptual, 8*, pg. 231-237. Copyright 2018 by Tschandl

ior of a lesion [9]. SDDI is performed in two settings: short-term (3 months) and long-term (6–12 months) dermoscopic monitoring [10]. The use of short-term SDDI is currently recommended to monitor individual suspicious lesions that require assessment over a longer period of time, such as lesions with a patient-reported history of change and benign dermoscopic appearance or an atypical lesion without a patient-reported history of change [10]. Long-term SDDI is recommended for the surveillance of atypical lesions in high-risk patients, such as patients with a history of multiple dysplastic nevi (Table 16.1) [7, 10]. Studies have shown that SDDI allows for the detection of melanomas diagnosed at an early clinical stage and reduces the number of unnecessary excisions of benign lesions in both a primary care and dermatologist setting [6, 9, 10].

Machine Learning

Machine learning is a type of artificial intelligence (AI) that utilizes deep learning algorithms (i.e., neural networks), powered by advances in computation and large data sets, to improve the accuracy of data assessments [1, 6]. Through the analysis of large image databases of cancerous lesions, machine learning has the potential to train computers to identify cancerous skin lesions (Fig. 16.2) [6]. In 2017, Esteva et al. were able to demonstrate that an artificially intelligent algorithm, a convolutional neural network (CNN), can classify skin lesions with comparable accuracy to a group of 21 dermatologists, after learning from a curated database of nearly 129,450 images [6, 11, 12]. The International Skin Imaging Collaboration (ISIC) published results of a cross-sectional study that compared the melanoma diagnostic performance of computer algorithms to the average performance of eight experienced dermatologists using 100 dermoscopic images of pigmented lesions. The study demonstrated that a machine learning fusion algorithm was able to exceed the performance of most dermatologists in the classification of 100 dermoscopic images of melanomas and melanocytic nevi [6, 13]. In 2017, the ISIC found that deep neural networks can classify images of benign pigmented lesions and melanomas with high accuracy, and can potentially improve der-

Table 16.1 Summary of the advantages and disadvantages of digital modalities—sequential dermoscopic imaging (SDDI), machine learning, digital teledermoscopy, and mobile teledermoscopy

	Utility	Advantages	Disadvantages
Sequential digital dermatoscopic imaging (SDDI)	• Short-term SDDI—Monitoring individual suspicious lesions (i.e., melanomas) over a long period of time. • Long-term SDDI—Surveilling atypical lesions in high-risk patients	• Can uncover dynamic changes in monitored lesions	• Depends on patient compliance (i.e., patients showing up for follow-up appointments)
Machine learning	• Useful in most diagnostic settings	• Improves diagnostic efficiency and accuracy	• Accessibility • Requires a data set with an accurate and extensive foundation of lesion morphologies • Depends on access to high-quality, digital databases • Less accurate in classifying rarer lesions
Digital teledermoscopy	• Ideal for remote providers and underserved populations	• Can be used by dermatologists or non-dermatologist providers	• Difficult to use and tedious process of transferring images • Quality of captured images varies
Mobile teledermoscopy	• Ideal for remote providers and underserved populations • Monitoring disease course and treatment response • Triaging patients	• Allows for convenient and and rapid capture of images • Only requires a mobile attachment, as most patients have access to smartphones • High diagnostic concordance with FTF diagnosis	• Most commercially available attachments are very expensive • Image and camera quality depends on the smartphone used • Limited in identifying certain dermoscopic features and complex lesions • Ethical concerns over the security of web-based platforms • Challenging for elderly patients

matologists' accuracy in diagnosing melanomas [14]. While machine learning has considerable potential for improving diagnostic accuracy and efficiency, there are limitations to its clinical practice. Machine learning is limited by its data sets, as image samples that do not display the full spectrum of morphologies for skin diseases can lead to inaccurate or delayed diagnosis [6]. In addition, machine learning is less effective in classifying less common lesions, such as pigmented seborrheic keratoses and amelanotic melanomas [1, 6]. Furthermore, for machine learning to achieve its maximum potential, machine algorithms require access to standardized, high-quality digital dermoscopic image databases (Table 16.1) [6]. Machine learning represents a harbinger of what is to come with the future of medicine and dermatology. Harnessing its potential can benefit practicing physicians, irrespective of any physicians' experience, and can revolutionize the way we deliver care and improve patient outcomes.

Teledermoscopy can be classified into live-interactive video consultation ("synchronous telemedicine") and store-and-forward (SAF) telemedicine ("asynchronous telemedicine") [5,

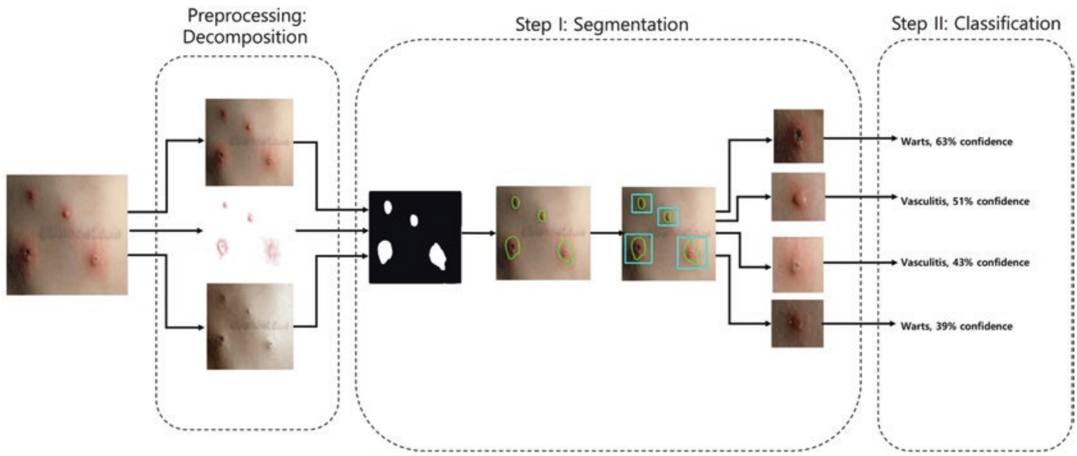

Fig. 16.2 Machine learning utilizes algorithms from large image databases to classify skin lesions. Reprinted from "AI-based localization and classification of skin disease with erythema" by Ha Min Son et al., 2021, *Nature*, *11*, pg. 5350. Copyright 2021 by Springer Nature

6]. Synchronous telemedicine involves the use of live, real-time, and collaborative telecommunications technology to facilitate a physician-patient encounter [5, 6, 15]. While the image quality of the transmitted video is inferior to that of captured images, live-interactive video consultation enables the clinician to clarify aspects of the history and teledermatologic examination and provide direct patient education and treatment instructions [16]. Asynchronous telemedicine uses store-and-forward (SAF) technologies—storing data for use in future consultation in the form of secure text, email, and internal or external SAF systems—to facilitate patient visits [5, 17, 18]. External SAF teledermatology systems operate separately from the primary electronic health records (EHRs) while internal SAF teledermatology systems function within existing EHRs [17]. Internal SAF systems offer many advantages over external SAF systems, including maintenance of records within one consolidated system, ability to capture other telemedicine benchmark data, and better continuity of care due to improved access to patient health records [17]. External SAF systems however can lead to fragmentation of care, communication lapses among clinicians of an interdisciplinary team, and privacy and security concerns [17]. One study found that an Epic-based internal SAF teledermatology system was able to improve access to dermatologic care in an urban city by decreasing wait times, reducing time to treatment or intervention, and increasing referral rates by primary care physicians [17]. In addition, diagnostic concordance between two teledermatologists was at least partially concordant in 79 of 79 cases (100%), similar to previously published studies [17]. Similarly, for patients referred through teledermatology and subsequently seen in the dermatology clinic, 89.7% of cases were concordant or partially concordant between the teledermatologists and in-person dermatologist. Furthermore, Epic-based SAF teledermatology can reduce the burden on safety-net hospital dermatology clinics by allowing for the effective and accurate management of cases remotely.

A comprehensive survey of active US teledermatology programs found that, within a single patient encounter, 72% of programs utilized SAF teledermatology, while 45% and 35% of programs used live-interactive and a hybrid of modalities (i.e., combination of SAF and live-interactive modalities), respectively [19]. The data suggests that SAF teledermatology is more popular compared to the use of a hybrid of modalities and live-interactive alone, likely due to increased convenience, lower costs, and higher quality of still images compared to live video

[19]. While hybrid teledermatology modalities combine live video and SAF clinical images, data suggests that it is less commonly utilized, partly because of significant bandwidth and storage space requirements and difficulty in practicing across multiple time zones [16]. As video communication technologies continue to advance in speed, quality, and accessibility, a hybrid approach of utilizing SAF and live-interactive technologies simultaneously may become more widely used.

Digital Teledermoscopy

With digital teledermoscopy, either a digital dermatoscope with image capturing capabilities or a digital camera interfaced with a dermatoscope is used to electronically send images to remote providers [5, 6]. Digital teledermoscopy utilizes secure web-based teledermoscopy platforms for enhanced skin self-examination (SSE) and can be used by specialists or non-dermatologist providers [5]. Digital teledermoscopy however is difficult to use and the quality of captured images varies. After images are captured by a digital camera, they are manually transferred either through a data transfer cable or a memory card reader and imported into an electronic medical record or proprietary Internet application for reading [20]. While the process of uploading, transferring, and storing information is tedious, new solutions are emerging such as the development of wireless transfer functionality to existing digital cameras as seen with the *microDERM®* (VISIOMED AG, Germany) wireless software (Table 16.1) [20].

Several studies suggested that the digital image montage technique is helpful to create a wide area digital dermoscopy (WADD) image. First, a smartphone or digital camera is used to obtain multiple consecutive dermoscopy images covering the entire skin lesion, with adjacent images overlapping by 20–30%. Second, the acquired images are transferred to the Photoshop software installed on a computer to be combined into a single image. The WADD concept can be applied to various situations such as preoperative dermoscopic mapping of skin lesions and follow-up of atypical dysplastic nevus syndrome or a congenital melanocytic nevus. As technology advances, current smartphones generally have the option of high-dynamic-range imaging, which can be used to combine multiple images taken with different exposures into one image to achieve a greater dynamic range (brightness range) than ordinary digital image technology. Given this feature of smartphones, the appearance of dermoscopic structures (including vessels) can be enhanced [1].

Mobile Teledermoscopy

Due to the ease of use and accessibility of smartphones, research efforts have been directed to optimize the use of mobile teledermoscopy in the clinical setting. Mobile teledermoscopy is a newer application of teledermoscopy where mobile devices (i.e., smartphones, tablets), with an attached polarized light dermoscopic lens, are used to capture and deliver dermoscopic images [5, 7, 21]. Images are captured by referring providers themselves in any location and forwarded for expert assessment, usually through a dedicated website or an app, such as Epic Haiku/Canto (Epic Systems Corporation, United States), in such a way as to maintain HIPAA standards for the use and disclosure of patient health information (PHI) (Fig. 16.3) [7, 20].

In the clinical setting, teledermoscopy is not only useful for diagnosing skin disease, but also for monitoring disease course and treatment response [22]. In addition to single-patient encounters, teledermoscopy has been successful in mass screening events and reaching underserved areas that are remote from local dermatologists [4, 23, 24]. Inclusion of clinical and dermoscopic images in a teledermatology visit has been shown to improve diagnostic accuracy by approximately 15% while adding only 1–2 min to consultation time [4, 23]. Massone et al., in 2008, carried out the first teledermoscopy study using mobile phones for image capture, storage, and as referral platforms for two teledermatologists. The study found that, in the

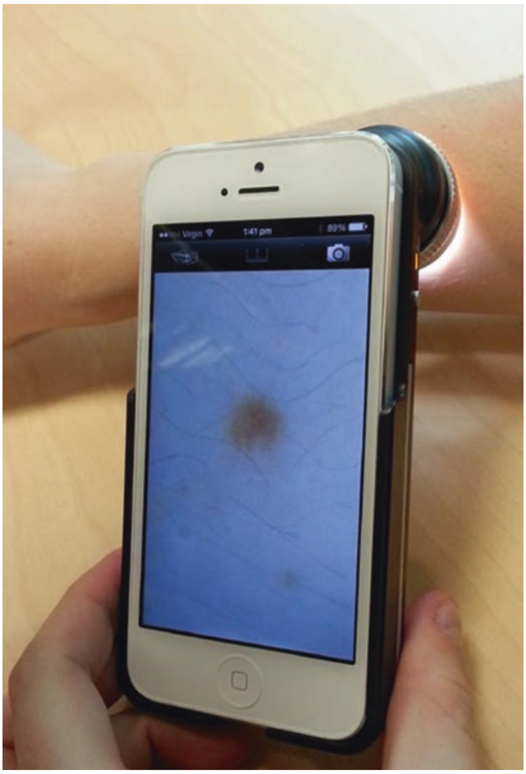

Fig. 16.3 Mobile teledermoscopy utilizes a smartphone with an attachable polarized light dermoscopic lens. Reprinted from "Consumer acceptance of patient-performed mobile teledermoscopy for the early detection of melanoma" by Horsham et al., 2016, *British Journal of Dermatology*, *175*, pg. 1301-1310. Copyright 2016 by John Wiley & Sons, Inc.

diagnosis of pigmented lesions, diagnostic concordance was 89% and 94% compared to FTF examination. Studies agree that incorporating dermoscopic images in a teleconsultation can improve the sensitivity and specificity of telediagnosis [25]. Studies have found that interobserver concordance between FTF and teledermoscopic diagnosis is excellent, particularly in assisting with teledermatological management of pigmented and nonpigmented lesions [25–27]. Kromer et al. compared the intraobserver diagnostic concordance in clinical and mobile teledermoscopic diagnosis of skin lesions among two teledermatologists and found an 85% and 79% concordance rate, respectively [28].

Not only does teledermoscopy increase diagnostic concordance, but also improves triaging and reduces treatment delay for more malignant tumors [27]. However, teledermoscopy is limited in diagnosing and managing very difficult lesions, such as melanoma in situ [25, 27]. Similarly, the management concordance between mobile teledermoscopy and FTF assessment is generally positive, with 81–91% full or partial diagnostic concordance between both modalities [4, 5, 29]. With the transition of care from FTF to telemedicine appointments, more research in teledermoscopy is underway to elucidate its benefits in the clinical setting.

Advantages

A major benefit of mobile teledermoscopy is that it requires only basic instruction to take adequate mobile teledermoscopy images [1]. A mobile teledermoscope is also lightweight, which allows for the convenient and rapid acquisition of images (Table 16.1) [30]. Given that mobile dermatoscope attachments are also relatively inexpensive compared to other teledermoscopic solutions, mobile dermoscopy has the potential to expand the reach of teledermoscopy to the average consumer [20].

Images are stored in a digital archive for follow-up, dermoscopic-pathologic correlation, and educational purposes, or sent to colleagues for second opinions [30]. Use of mobile teledermoscopy for the purpose of triaging patients has been shown to be both feasible and economically viable [5, 31]. While there are a variety of popular devices (Dermlite, USA; Canfield Scientific, USA) available on the market that can be attached to smartphones for effective dermoscopy, the main disadvantage of these devices is their high cost, as many start at approximately 700 USD (Table 16.1). Nonetheless, more affordable dermatoscopes have emerged for the average consumer. The economical mobile dermatoscopes include the DermLite DL1 (Dermlite, USA) [285.00 USD], DermLite HUD (Dermlite, USA) [99.95 USD], dyplens® (Firstcheck Ltd., New Zealand) [29.95 USD], MedicMind Skin Scope (MedicMind, New Zealand) [75.00 USD], Molescope™ (MetaOptima Technology, Canada) [99.00 USD], and Molescope™ II (MetaOptima Technology, Canada) [299.00 USD] (Table 16.2) [5].

Table 16.2 A list of the commercially available digital dermatoscopes, and mobile attachments with their respective smartphone app

Digital dermatoscope	Interfacing device (mobile device or camera)	Requires separate image capturing device? (Y/N)
Dermlite cam*	N/A	N
Dermlite DL1	Mobile device	Y
Dermlite DL200 (HR and hybrid)	Mobile device or digital camera	Y
Dermlite DL4/DL3N	Mobile device or digital camera	Y
Dermlite FOTO X/X plus	Mobile device or DSLR camera	Y
Dermlite Foto II pro	Any Nikon or canon full-frame or 2/3 frame DSLR camera	Y
DermLite HUD	Mobile device	Y
Dermlite handyscope with Handyscope 2 app/FotoFinder hub	Mobile device	Y
Dyplens/Firstcheck app	Mobile device	Y
VEOS DS3	Apple mobile devices	Y
Canfield VEOS HD1/VEOS HD2	Apple mobile devices	Y
Canfield VEOS SLR	Canon SLR camera	Y
MoleMax HD	Built-in video or image capturing device in dermatoscope	N
DermoGenius II	Digital camera	Y
DermoGenius ultra	Built-in video or image capturing device in dermatoscope	N
Dynamify wireless dermatoscope	Built-in video or image capturing device in dermatoscope	N
Illuco IDS-1100 dermatoscope	Mobile device or digital camera	Y
DE300 polarizing Dermatoscope/dermascope	Built-in video or image capturing device in dermatoscope	N
DE350 wireless polarizing Dermatoscope/dermascope	Built-in video or image capturing device in dermatoscope	N
FotoFinder Medicam 1000	Built-in video or image capturing device in dermatoscope	N
Heine NC2 Dermatoscope/iC1 app	Apple mobile device	Y
Heine DELTA 20 T Dermatoscope	DSLR camera	Y
Heine iC1 Dermatoscope/iC1 app	Apple mobile device	Y
Molescope/molescope II/Molescope app	Mobile device	Y
microDERM Luminis	Digital camera	Y
MedicMind skin scope	Mobile device	Y

Another advantage of SAF teledermoscopy is that it can improve accessibility to specialists while reducing healthcare costs, the number of "no-shows" at FTF clinics, and surgery waiting times compared to paper referrals [4, 5, 31]. A study by Börve et al. found that smartphone teledermoscopy referrals could be assessed within 24 h, reducing the median time to diagnosis and treatment for all skin cancer types and allowing for more efficient management (such as surgical treatment when required) in skin cancer patients on their FTF visit [31]. Smartphone teledermoscopy referrals were also found to reduce waiting times for first-time FTF visits with dermatologists and for primary treatment of melanoma, melanoma in situ, squamous cell carcinoma, squamous cell carcinoma in situ, and basal cell carcinoma [31]. Similarly, Lim et al. demonstrated that teledermoscopy reduced the mean waiting time for a first assessment by a dermatologist was reduced from 114 to 39 days [31].

Teledermoscopy also reduces the number of inaccurately triaged referrals and frees up time for more urgent cases involving potentially life-threatening cancers [23, 31]. The IMAGE IT trial by Tan et al. found that teledermoscopy approximated 100% sensitivity and 90% specificity for detecting melanoma and nonmelanoma skin cancers [29]. Of significance, 74% of lesions were able to be managed by the general practitioner (GP) without the need to follow-up with a dermatologist [29]. As a triage and monitoring instrument, teledermoscopy has also been shown to reduce the number of unnecessary and urgent referrals, wait times, and overall healthcare cost [4, 5, 31]. A similar study involving a Virtual Lesion Clinic (VLC) by Congalton et al. found that teledermoscopy had a positive predictive value of 63% in the diagnosis of melanomas [32]. In addition, VLC operation for 1 year resulted in cost reductions in excess of $364, 000 (or $1174/patient) [32].

Teledermoscopy can also allow for consultation with specialists in remote or medically undersupplied locations, which is especially helpful in locations where there are shortages of dermatologists [4]. Teledermatology can also be a useful educational tool for dermatologists and other health care providers, the latter who can send an image of a difficult rash or lesion to a more experienced colleague for diagnosis and management [4]. It is also useful for monitoring patients with chronic conditions that require frequent follow-up and changes for treatment optimization (Table 16.1) [4, 5]. Despite reduced FTF interaction with providers, especially with SAF or asynchronous teledermoscopy, patients report satisfaction with mobile teledermatology services, citing improved waiting times, convenience, reassurance, and privacy [4, 5, 29, 33]. One study found that patients had a positive perception of mobile teledermoscopy and believed it would improve their skin self-examination and surveillance for cancer and motivate them to check their skin more often [4, 5]. Most importantly, patients reported feeling comfortable and competent with taking dermoscopic images with only minimal instructions. Similarly, parents of young patients also expressed willingness to use a pediatric teledermatology service if it was available [4, 5].

In practice, mobile teledermoscopic lenses would be available to patients by their dermatologist or primary care provider and attached to patients' smartphones, interfacing with a mobile app for image collection and transmission to a HIPPA-regulated database. Dermoscopic lenses would either be covered by insurance or, in the case of more affordable mobile teledermoscopic lenses, be an out-of-pocket cost available to the masses. Dermoscopic lenses would enhance the quality of captured images to meet optical magnification standards, limiting user error and improving the accuracy of diagnoses.

Disadvantages

The disadvantage of mobile teledermoscopy is that the camera quality of older smartphones is typically inferior to digital cameras [20]. However, the newer generation of cellular phones does not have the limitations in image quality as seen in optical systems presented with older devices. Furthermore, in-built cameras seen with the new generation of mobile smartphones have improved image quality [20].

Teledermoscopy in Skin of Color (SOC) Patients

Individuals of African descent or skin of color (SOC) patients have brown-black skin and eyes, and rarely get sunburned when exposed to sunlight. Furthermore, they are classified as skin types V and VI, according to the Fitzpatrick scale [5]. Dermoscopic patterns of skin lesions (i.e., pigment and vascular network) often differ depending on a patient's Fitzpatrick skin type [5, 34]. In skin types V and VI, acquired melanocytic nevi are dermoscopically defined by a reticular pattern with a tendency toward central hyperpigmentation and high frequency of gray and black [5, 34]. Nevi in skin types V and VI also show similar characteristics to melanocytic lesions exposed to sunlight, with the following structures: black dots, pigment blotches, prominent network, and decreased areas of hypopigmentation [35]. In contrast, patients with skin types I and II, and often skin types III, have a tendency toward lighter brown color with uniform distribution, and multifocal hyperpigmentation and hypopigmentation [5, 34, 36]. Despite differences in dermoscopic features, diagnostic accuracy in light and dark skin populations is similar, since darker skin does not interfere with the identification of single dermoscopic features [5, 35]. The use of new-generation dermatoscopes with sufficient light-emitting diode illumination is helpful in difficult cases where use of a strong light source is needed to evaluate lesions in SOC patients, as darker skin absorbs larger amounts of UV-light than lighter skin [5, 35]. Nonetheless, presentation of diseases in patients of SOC is underrepresented in current digital resources, stressing the need for educational resources to comprehensively illustrate pathology across all skin tones [37]. Additional research also needs to be performed in areas of diagnostics and surveillance so as to optimize evaluation of lesions in SOC patients [37].

Limitations of Teledermoscopy

While teledermoscopy is efficacious in the assessment of most lesions, it is limited in cases involving complex melanocytic and hypo- or nonpigmented lesions, and in the setting skin cancer screening. In addition, teledermoscopy brings out ethical issues regarding the safe and confidential transfer of patient information.

Complex Melanocytic and Hypo- or Nonpigmented Lesions

In 2016, de Giorgi et al. assessed the efficacy of teledermoscopy in evaluating complex melanocytic lesions by having 10 different teledermatologists analyzing 10 challenging pigmented lesions via telemedicine or in-person [5, 21, 38]. The interobserver agreement (K[1]) between teledermatology and FTF assessment was 0.38 and 0.60, respectively, indicating that was final histopathological diagnosis compared with the final histopathological diagnosis, teledermatology was significantly inferior to FTF dermatology [5, 38]. Interestingly, in this study, the diagnostic concordance of telediagnosis decreased after teledermoscopic observation [38]. The researchers attributed the low interobserver concordance to the complexity of select cases that were evaluated during the study, such as Spitzoid proliferation and atypical melanocytic nevi of the elderly, which represent potential diagnostic failures due to their complicated dermatoscopic characteristics [5, 21, 38]. Histopathologically, Spitzoid lesions exhibit peripheral, irregular radial streaks and pseudopods, while atypical melanocytic nevi of the elderly exhibit widespread regression [38]. In atypical melanocytic nevi of the elderly, widespread regression is a significant confounding dermoscopic parameter because it tends to cover or destroy other parameters thereby preventing an accurate diagnosis (Fig. 16.4) [21, 38]. These dermoscopic features are especially confounding and can justify the low diagnostic concordance between telediagnosis and histopathology in this study.

In another study, Fabbrocini et al. assessed the reliability of teledermoscopy for diagnosing rare and atypical lesions. Many of the lesions were characterized by poor and/or absent pigmentation, the absence of regular network, and a diameter < 5 mm [5, 21, 39]. The study demonstrated that certain dermoscopic elements are identified with more or less ease through teledermoscopy compared to FTF diagnosis. Dermoscopic features, such as leaf structures, pseudocysts,

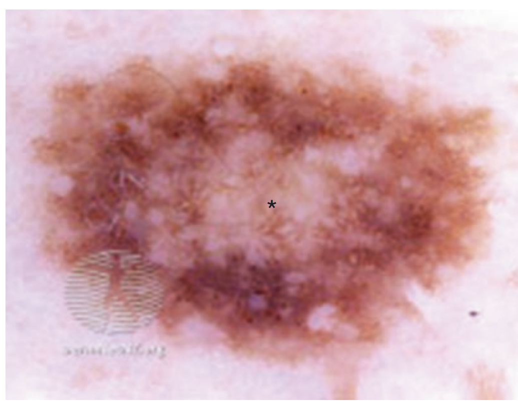

Fig. 16.4 Atypical melanocytic nevi represent a diagnostic challenge due to their complex dermoscopic features, such as regression (asterisk*), which can obscure other visual parameters. Reprinted from DermNet. https://dermnetnz.org/imagedetail/23873?copyright=&label=. Copyright 2022 by DermNet

comedo-like openings, "blue-white structures," and "blotches," are detected with the same frequency in FTF assessment and teledermoscopy [5, 33]. However, other dermoscopic features, such as pigment network, regression structures, and diffuse pigmentation, are more easily visualized in teledermoscopic versus FTF observation, whereas vascular pattern, radiated streaks, and spots/globules are less frequently detected [5, 21, 39]. The study also underlined the ineffectiveness of SAF teledermoscopy in evaluating scarcely pigmented lesions (52%) compared to FTF assessment (66%), although both modalities demonstrate poor concordance with histopathological diagnosis ($p < 0.05$) [39].

Skin Cancer Screening

Most skin cancers, especially melanomas, are initially detected by either patients or their families [40]. In the absence of population-based skin cancer screening programs, naked-eye skin self-examination has become the recommended method for skin cancer prevention and early detection by cancer agencies [40].

Previous studies have approximated the sensitivity of skin self-examination to vary widely from 25% to 93% [40]. While dermoscopy has improved the sensitivity for diagnosing skin cancers, in addition to most melanocytic and nonmelanocytic lesions in FTF encounters [20], evidence for use in the setting of skin self-examination is contradicting. In one study, the efficacy of mobile teledermoscopy was assessed in comparison to skin self-examination (control). Although mobile teledermoscopy had a high sensitivity (≥75%) for identifying skin cancers (pigmented and nonpigmented), more cancers were missed with mobile teledermoscopy ($n = 17$) than control ($n = 7$) [5, 40]. In this study, participants utilizing mobile teledermoscopy more commonly missed basal cell carcinomas (44%) than did participants in the control group (21%), indicating that instructions for digitally capturing basal cell carcinomas require further improvement [5, 40]. It is thought that decreased detection of skin cancers may also be due to lower rates of whole-body skin self-examination with mobile teledermoscopy [5, 40]. With fewer numbers of FTF appointments, there is an increased risk of so-called "unimaged melanomas" which are incidentally discovered by the dermatologist as part of the FTF examination but often overlooked by referring PCPs. Furthermore, loss of direct patient-physician encounters carries the risk of diagnostic and treatment delays given that there are fewer earlier or incidentally diagnosed melanomas [5, 41].

Monitoring of atypical lesions concerning for malignancy, instead of screening for new lesions, through mobile teledermoscopy has been proposed as an effective method for skin cancer prevention [42]. On the basis that melanomas change significantly over time, digital follow-up of atypical melanocytic lesions has been a proposed strategy to recognize melanomas that may lack distinct dermatoscopic features at baseline but gradually evolve over time [42]. There is increasing evidence that the two-step method of digital follow-up, digital dermoscopy with total-body photography (TBP), can also aid in the early detection of melanoma in high-risk patients (Breslow thickness, body site location, histological subtype, history of prior melanomas) [26, 43]. It is well documented that subsequent melanomas in patients with a history of primary melanomas tend to be thinner at diagnosis than the patient's first melanoma [43]. Body site location of melanomas in high-risk populations also shows a pattern of body site distribution (primarily on the limbs in women and trunk in men) and histological subtype (superficial spreading melanoma and melanoma in situ) [43]. The combination of SDDI and TBP also has been shown to improve the diagnosis of clinically featureless and de novo melanomas overlooked by dermoscopy alone, and has been proposed as a more sensitive strategy in melanoma screening in high-risk patients [43].

Mobile teledermoscopy has very high cancer detection rates for patients presenting with specific skin lesions, especially in high-prevalence settings [44]. The primary categorical diagnostic concordance rate between mobile teledermoscopy and in-person assessment is 82% (95% confidence interval 0.73–0.89), with a Kappa coefficient of 0.62 indicating good agreement [45]. Lesion-directed teledermatological assessments, especially lesion-directed SAF procedures, are time-efficient and have similar detection rates as in-person lesion-directed assessments [44]. In several studies, the reliability of teledermatology-based management recommendations has been shown to be comparable to FTF consultations. Feasibility and reliability for cancer detection, in addition, have already been shown in high-prevalence settings [44]. Store-and-forward mobile teledermatology can be utilized for skin cancer screening for lesions of concern but precaution is advised when evaluating high-risk patients requiring full-body examination or patients with morphologically complex and pigmented lesions [5].

Other Limitations

Teledermoscopy limitations include technological challenges in elderly populations and ethical concerns regarding the confidential and secure exchange of data [5, 41]. Concerns regarding the confidentiality of data can be addressed by encrypting data through medical-related smartphone apps, use of anonymity, or transfer of data to encrypted platforms (Table 16.1) [5, 41]. Another concern is the standardization of image quality and regulation of smartphone apps [41]. Some apps have a low diagnostic sensitivity that may induce false negatives, erroneously reassuring patients to not seek specialist care [41]. While many of these apps are certified by regulatory bodies, certification does not guarantee effective application function and diagnostic performance [41, 46]. Therefore, greater control of these smartphone apps by federal authorities, including the US Food and Drug Administration (FDA), is necessary to guarantee mobile applications are safe for patients to use [41, 46, 47]. Similarly, standardization of image and service equipment is required for adequate functioning of a teledermoscopy service. Practical guidelines from the American Telemedicine Association (ATA) advised display systems have at least 24 bit-color depth in 2008 and an image resolution of 800x600 pixels and 1024x768, preferably, in 2012 [21]. Other standardization features include techniques such as ambient conditions (illumination, background, and camera position), patient pose, patient consent, privacy, and confidentiality [21]. Altogether, these features can alter the appearance of the lesion, emphasizing a need for standardization to allow for the consistent use of valid and reliable instrumentation that maximizes image quality and accurate diagnosis [21]. Once standardization techniques are implemented, image acquisition could be utilized for broader population-based screening [21]. Future advances in mobile teledermatology may address these concerns and increase the accuracy of self-skin examinations.

Another anticipated difficulty with teledermoscopy is the omission of specific areas that are either difficult to access, such as hair (i.e., apical melanocytic lesions), the back, or the ear, or those considered sensitive (i.e., genitalia), which could interfere with the lesion identification [5, 41].

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17 Teledermatopathology

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Introduction

Pathology is the scientific study of tissue and bodily fluids to establish the cause and effects of the disease. It is considered one of the foundational pillars of modern medicine and underpins every aspect of patient care, from diagnostic and prognostic testing and treatment recommendations to establish patterns of disease within populations and therefore disease prevention [1]. Since pathology represents the bridge between medicine and basic science, it relies on the incorporation of new technologies into its practice. The practice of anatomic pathology, which includes dermatopathology, has historically relied on the visual interpretation of cellular biology images, referred to as histopathology. In conventional histopathology laboratories, tissue samples are processed and cut into thin sections on glass slides for examination under the microscope. The pathologist then interprets the histopathological findings and renders a diagnostic report, typically communicating the findings to the referring clinician through a digital laboratory information system (LIS). The tissue sample block and glass slides are then stored for at least 10 years in the laboratory [2]. It is widely established that pathology and laboratory information has a substantial effect on clinical decision-making [3]. Becich et al. published that 50–70% of all clinical decisions regarding patient care were attributed, in part, to clinical and anatomic pathology data [4]. The Mayo Electronic Result Enquiry System revealed that the majority of relative patient data in their system was derived from pathology services (94%), with radiology (3%), patient data (1%), electrocardiography (1%), and surgery (1%) representing only minor components of the patient's individual medical record [5].

The Institute for Healthcare Improvement has proposed a triple aim for future healthcare models: (1) improving the health of populations, (2) improving the patient experience of care, and (3) reducing the cost per capita for healthcare [6]. In recent years, many have advocated a fourth aim of physician wellness due to emerging evidence that healthcare provider "burnout" undermines the ability to accomplish the former three aims. As the United States moves away from fee-for-service care and towards value-based care, "population health" or "precision medicine" strategies are at the forefront of new health care models. This will dramatically place increased responsi-

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bility on healthcare providers to demonstrate cost-effectiveness in their practice of medicine. According to the NIH, “Precision Medicine” is defined as “an emerging approach for disease treatment and prevention that considers individual variability in genes, environment, and lifestyle for each person” [7]. For these individualized treatment decisions to be made, pathologists must provide clinicians with increasingly complex reports that include multiparameter analyses ensuring that the right patient receives the right treatment at the right time [8]. Today, most pathology reports must include specific parameters, such as tumor size, tumor pattern of growth, surgical margins, degree of cellular differentiation, associated precursor lesions, phenotyping with immunohistochemical staining, and genomic and proteomic profiling to determine eligibility for targeted therapy. In recent years, the number of practicing pathologists has dramatically declined, despite the increasing demand from an aging patient population. This decline is predicted to continue until at least 2030 [9]. All of these factors signal an emerging crisis in pathology-related care; therefore, pathologists must adapt and incorporate new technologies that will increase the efficiency and accuracy of their practice.

History of Digital Pathology

“Telepathology” was first introduced by Dr. Ronald Weinstein in 1986, where he developed a system involving a microscope with a video camera and a remotely controlled robotic arm that could project histopathologic images to a remote monitor for pathologist interpretation [10]. Although the components of this technology were primitive at the time, the successful demonstration of this concept to remotely diagnosis a patient’s biopsy, in real-time, halfway across the United States was revolutionary. While pathologists have been sharing still photographs of focal microscopic regions of interest within the glass slide for teaching and research documentation for over a century, the inability to remotely review the “entire” slide was the limiting factor for the

Fig. 17.1 Modern slide scanners have the capacity to scan a huge number of slides daily. This practice has enabled some laboratories to become fully digitalized. Each scanned slide with this system requires the same digital storage space as approximately 1000 MRI scans

implementation of “telepathology” in routine diagnostic care. In the 1990s and early 2000s, analog technologies were gradually replaced by digital counterparts and whole slide imaging scanners first became commercially available. Whole slide imaging (WSI) involves the capture of the entire section of tissue into a digital image (digital pathology), which is a prerequisite for a digital histopathology workflow to fully replace the microscope. Today, technical advances in processing speed and decreased costs have made WSI the standard for future, large-scale, high throughput digital pathology workflows (Fig. 17.1).

How Does Digital Pathology Work?

The initial preanalytical workflow steps for tissue processing in the histopathology laboratory remain largely unchanged. Instead of glass slides being directly distributed to the pathologists, a digital pathology workflow routes these barcoded glass slides to a digital scanner for WSI where the tissue is scanned at 20x or 40x magnification simulating a traditional microscope in a computer [11]. Current devices, such as the Philips Intellisite, can scan up to 60 slides per hour with a capacity of 300 slides that can be continuously loaded [12]. The Aperio GT 450 can scan 85 slides per hour with a capacity of 450 slides [13]. In addition to these scanner devices, WSI requires additional dedicated equipment, such as dedicated high-definition monitors, and professionally maintained and secured servers for data storage (typically >10 Mbit/s). These requirements are similar to radiology, where PACS (Picture Archiving and Communication Systems) have been implemented to guarantee that stored data produces images that are identical to that at the time of reporting [14]. Once the slide images have been fully digitized, these store-and-forward case files are assigned to a pathologist for interpretation either on-site in the laboratory or remotely. Additional orders for deeper sections and special and/or immunohistochemical stains are placed in the LIS and will be routed to the scanner for digitization and case consolidation of images. New WSI software is continuously being developed to further facilitate the benefits of a digitized image (see sections: Advantages and Disadvantages, Digital Pathology with IHC, The Future of Digital Pathology).

Advantages and Disadvantages of Digital Pathology Workflow

Diagnostic Accuracy and Impact on Patient Care

WSI is designed to be a precise replica of the glass slide however it may not be an identical copy in every single way. Diagnostic concordance between digital and glass slide pathology is important to determine before implementing telepathology. Multiple studies have compared diagnostic concordance between WSI and conventional light microscopy using glass slides and a microscope. A recent meta-analysis comprising 25 publications and 10,410 samples found a 98.3% (95%CI (97.4–98.9)) diagnostic concordance rate between WSI and light microscopy [15, 16]. The majority of discordances were related to the assessment of nuclear atypia/grading of dysplasia (57%), followed by challenging architectural features (26%, e.g., determining microinvasion) and identification of small objects (16%, e.g., Helicobacter pylori, mitoses). The current FDA approvals for WSI are based on a non-inferiority study where there was an equal interpretative discordance rate between glass slides (4.6%) and WSI (4.9%) slides when each slide type was reevaluated ≥4 weeks after initial diagnosis. Major WSI vs. glass discordance rates was not significant at 0.4% (95% confidence interval (CI) (−0.3–1.01)). In a review of their discordant cases, no consistent inaccuracies due to WSI were observed. In regards to dermatopathology, the highest reported discordance rates have been with the interpretation of melanocytic lesions [17, 18]. Until larger longitudinal studies become available, digital pathology workflow will be considered an adjunct, as assessment of unique scenarios, such as examination of tissue under polarized light (i.e., amyloid, foreign bodies, etc.), will still require the use of conventional light microscopy [19].

Consultations and Enhanced Patient Care

Workflows that incorporate digital pathology offer numerous advantages over conventional light microscopy. The most obvious advantage is the ability to instantaneously share the microscopic image files with a pathology colleague for expert primary diagnosis or second opinion consultation. Current second opinion workflows require the mailing of glass slides and sometimes the tissue block to the consultant's laboratory, delaying the turn-around-time of results by a week or more. Using virtual slides for consultations saves between 24 and 96 h per case from glass slide transportation, which helps to shorten the time to receive a response for a second opinion [11]. Of note, dermatopathology is in high demand for these systems due to the high interobserver variability and short supply of these specialists worldwide. It has been noted that significant diagnostic discrepancies (i.e., diagnostic differences that affect a patient's treatment and prognosis) vary from 14% to 28% in skin diseases. These discrepancies tend to be lower when the cases are reviewed only by dermatopathologists than by general pathologists [20–22]. In this context, finding ways to connect dermatopathologists with other physicians is a major advancement in improving patient care. One technical implementation barrier worth mentioning is the need for a vendor-independent platform for WSI that is compatible with multiple WSI file formats. Recently, a group within the Netherlands has initiated a digital pathology platform for the exchange of WSI for teleconsultation and virtual expert panels [23].

For large healthcare systems, digital pathology allows for the uncoupling of the technical and professional components and the creation of a hub-and-spoke telepathology network where subspecialty AP diagnostic services of excellence can provide expert diagnostic care for lower volume locations conventionally covered by general surgical pathologists. Routine digital pathology consensus conferences among in-house colleagues reviewing multiple complex or equivocal cases can also be conducted with relative ease on a daily basis, enhancing diagnostic accuracy and reducing medical-legal risk for difficult diagnostic scenarios. UCLA recently published its experience in deploying a regional digital pathology subspecialty consultation network [24]. The complexity and cost-benefit tradeoffs involved in setting up their digital consultation system are discussed in the "implementation" section of this chapter. Published experiences from the Eastern Quebec Telepathology Network (22 hospitals and 1.7 million patients), which completely replaced light microscopes with digital pathology, outline the many advantages of this model including reduced diagnostic delays, service breaks, and patient transfers to urban centers. However, they highlight the importance of the dynamic collaboration of the pathologist-technologist-clinician trio and how this relationship determines the success or failure of a telepathology initiative. They discovered that sites lacking on-site pathologists transferred certain clinical duties, remunerations, and legal responsibilities from the pathologists to technical assistants, altering the department's internal structure [25, 26].

Digital Tools for Quantitative Analysis and Improved Patient Care

Advanced software systems are being developed to compliment WSI workflows and reduce manual errors through an automated system that collates all available case histopathological, clinical, and molecular information. Studies on image perception have shown that pathologists initially evaluate the digital image with an initial glance in order to assess the overall image properties. Whereas the lowest magnification available for light microscopy is 2x, WSI using high-resolution monitors allows for an enlarged 1x evaluation of the entire tissue section to then quickly focus on regions of interest (i.e., suspected malignant foci) [27]. This 1x feature is not only faster than 2x light microscopy but also decreases the chance of the pathologist missing an important section of tissue during this initial scanning step. Some additional innovative features include e-slide annotation of foci of interest (which can be shared with colleagues), numeric counter tools for annotated foci (i.e., mitoses, etc.), measurement tools for tumor size and margin clearance, grids, image capture for inclusion into pathology reports, and synchronization of multiple e-slides for evaluation of deeper levels, special stains, and immunohistochemical stains generated from the same tissue block.

As these tools allow the pathologist to capture quantitative data points associated with the patient's sample and subsequent diagnosis, machine learning tools (artificial intelligence) are being developed to utilize this data for future enhancements. (Table 17.1, Fig. 17.2).

Recent applications of incorporating high-resolution images of gross specimens into the LIS to accompany conventional gross descriptions have improved gross-histopathologic correlation and orientation of surgical resections [28–30]. Similar applications of attaching clinical dermatology and dermatoscopic images to individual biopsy accessions will significantly improve the clinical-pathologic correlation. There is robust literature detailing the clear advantages of incorporating clinical and derma-

Table 17.1 Examples of Software

1. Aperio ImageScope, Leica, Deer Park, the United States
2. Sectra Digital Pathology Solution, Sectra, USA
3. Cytomine, Cytomine Corporation, Belgium
4. Orbit, Idorsia Pharmaceuticals, Switzerland
5. Philips Intellisite Pathology Solution, Philips Medical Systems the Netherlands

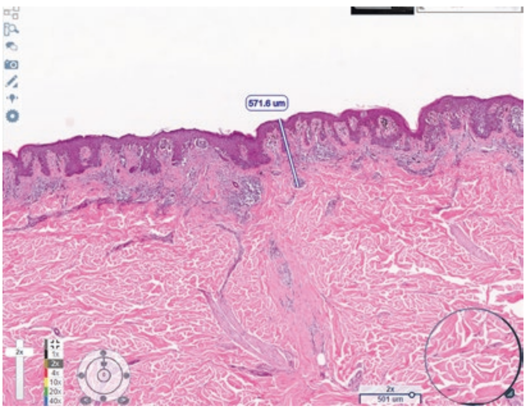

Fig. 17.2 Standard software allows control of the movement of the slide, various microscopic resolutions (mimicking the objectives of a conventional microscope), and allows basic measurements

toscopic images with histopathological interpretation; in particular, early detection of skin cancers, such as melanoma and the recognition of rare melanoma variants [31–33]. The lack of integration between conventional light microscopic workflows and EMR systems makes retrieval of these clinical and dermatoscopic images cumbersome and time-consuming for routine use. As value-based care reimbursement models expand, pathologist compensation for additional clinical-pathologic correlation is likely. Recently CMS has released new CPT codes for pathology consultation (see section: Regulatory Requirements and Billing Compliance for Patient-Related Digital Pathology WSI in the United States) [34].

Digital Pathology and Pathologist Wellness

An important obstacle for implementing digital pathology is the pathologist's willingness to adopt digital pathology for routine use in primary tissue examination. Even though validation studies have shown excellent diagnostic accuracy, some pathologists do not feel confident in making diagnoses without reviewing glass slides through the light microscope [35, 36]. A published 5-year digital pathology implementation experience on 6700 cases/35,500 slides reported >90% utilization of digital pathology only for initial slide evaluation [37]. Almost 10% of these cases required additional glass slide evaluation by light microscopy. Others have also reported on the importance of having glass slides available on request for digital pathology workflows. Published shared experiences using digital pathology at Memorial Sloan-Kettering Cancer Center included an experience survey with pathologist feedback revealing that 48% of respondents would have not felt comfortable with digital pathology sign-out without the option for requesting glass slides on an as-needed basis. Additionally, 15% of respondents felt uncomfortable even with glass slides available. Regardless, overall 91% of respondents thought digital pathology reduced turn-around times, helped in decision-making regarding repeat ancillary studies (96%), and was useful for reviewing prior case materials (83%) [19].

During the period of social distancing due to the COVID-19 pandemic, the use of telepathology abruptly increased, as did most telemedicine services. In certain hospitals, trained staff were assigned to scanning glass slides and pathologists reviewed the cases from home. Despite adding this extra step to the regular workflow, many hospitals reported no delays in diagnostic reports or major difficulties adapting to this system [38, 39]. As a matter of fact, pathologists with prior experience using WSI reported reviewing digital slides faster than glass slides, suggesting increased work productivity once trained with this new technology [40, 41]. A recent randomized prospective study published by Memorial Sloan-Kettering Cancer Center evaluating a remote signout workflow (non-CLIA certified facility) utilizing their WSI digital pathology system through a secure virtual private network connection and consumer-grade computers and monitors found a major diagnostic equivalency of 100% between digital and glass slide diagnoses and an overall concordance of 98.8%. Intraobserver concordance metrics included top-line diagnosis, margin status, lymphovascular and/or perineural invasion, pathology stage, and ancillary testing. The median whole slide image file size was 1.3 GB. Monitor sizes used ranged from 13.3 to 42 inches (47% participants using a monitor less than 14 inches) with a resolution of 1280 × 800–3840 × 2160 pixels. Residential Internet bandwidth (download speeds) were deemed adequate (median 94 megabits per second, range 3–385 Mbit/s). WSI latency was reportedly slower with lower network connectivity. On a five-point Likert scale (1-very poor, 5-very good), all users rated the WSI Slide Viewer equal to or >3, with a median rating of 4 (i.e., good). Comfort level using WSI for remote sign-out of primary diagnosis with the availability of glass slides had a median rating of 5, where 90% of readers responded ≥4 (i.e., good) [11].

Cost-Effectiveness of Digital Pathology Implementation

Building a business proposal for digital pathology is necessary to solicit buy-in from hospital and/or health system administration. Those who advocate for digital pathology becoming a new standard of care frequently cite gains in workflow efficiency and overall productivity. Additionally, digital pathology offers cost savings in regard to glass slide storage, shipping costs, and administrative staffing. However, implementation of digital pathology workflows incurs additional fixed costs, such as WSI scanners, monitors, secured servers, laboratory technicians/assistants, and IT support, as well as variable costs, such as hard drive storage space. Concerns for continued expenses of technology upgrades have been potentially alleviated by reports of increased productivity [42]. Since the costliest components of digital pathology implementation are fixed, digital pathology initiatives have mostly been reported in large hospital systems with large annual specimen collections [43–48]. Many of these published reports fail to include the discrete criteria used in evaluating their cost-effective assessment. Different digital blueprints may be required for distributed healthcare networks compared to single institutions or small physician-owned labs. Unless there is a complete transition to a digital pathology workflow, the cost-efficiency balance may be riskier, as approximately 5–10% of cases will still require review by light microscopy [15]. At the time of this publication, it appears that no comprehensive long-term (> 5 years) cost-efficiency analyses for full departmental digital pathology implementation have been published. Memorial Sloan-Kettering Cancer Center's published digital pathology implementation experience included a gradual transition from research WSI to routine diagnostic WSI in a subset of cases interfaced with their LIS during the period of 2015–2017 (n = 424,901 WSI) [19]. The examination of surgical resection specimens frequently requires a review of the initial biopsy slides. The authors reported a 93% reduction in glass slide requests for this purpose. Additionally, the availability of WSI with immunohistochemical stains from the prior biopsy material resulted in pathologists ordering fewer ancillary studies by up to 75.4%. The authors anticipated a savings of $113,400 at their institution, with a median number of 756 cases per year with documented WSI review. Their prescanning and postscanning cost analysis, incorporating budgetary considerations such as required personnel (i.e., slide file clerks, slide scanning), hardware (including capital equipment purchases), software, service agreements, IT infrastructure, digital storage, glass slide physical asset storage, and off-site storage vendor services (i.e., filing, retrieving, delivery costs) during a 5-year period (2014–2018), projected an annual savings of more than $267,000 secondary to personnel restructuring, and decreased vendor services and a $1.3 million projected savings during a 5-year period (2019–2023). For their partially phased digital pathology implementation, they determined an anticipated operational break-even point of 7 years [19].

A published UK digital pathology implementation, where reimbursements are more standardized (UK-NHS compared to the US), evaluated efficiency gains and recoupment of financial implementation costs [42]. Their teaching hospital encompassed 45 full-time pathologists, 80,000 specimens, and a nine million pound annual budget. According to their estimates, costs for digital pathology implementation would break even after 2 years and 1 year with productivity gains of 10% and 15%, respectively. They cautioned that productivity gains of 5% would amount to a permanent financial loss compared to physical glass slide light microscopy.

Another notable phased-in digital pathology implementation experience was published by Ho et al. (2014), from the University of Pittsburgh School of Medicine. This healthcare system's pathology department accessions 219,000 cases annually from their tertiary care academic medical center and multiple community hospitals spread throughout western Pennsylvania. They predicted a $12.4 million-dollar savings over a 5-year period due to anticipated improvements in pathology productivity and histology lab consolidation. Additionally, the implementation of digital pathology allowed these community hospitals to access subspecialty pathology services (compared to general surgical pathology) and an additional projected $5.4 million savings from costs associated with the over- and undertreatment attributed to incorrect diagnosis. They based this prediction on payer/provider cost sharing calculations on annual over- and undertreatment costs for breast cancer and melanoma, which were estimated to be approximately $26,000 and $11,000 per case, respectively, and extrapolated to $21,500/case for other cancer types [22] (Fig. 17.3).

Fig. 17.3 Cheaper systems can be fashioned with a smartphone, teleconference application (e.g., Skype, WhatsApp), and a microscope smartphone adapter (e.g., Labcam, www.ilabcam.com/products/labcam-for-iphone). This is particularly useful for frozen section assessment of Mohs surgery where the surgeon is able to consult a dermatopathologist at a remote location

Regulatory Requirements and Billing Compliance for Patient-Related Digital Pathology WSI in the United States

At the time of this publication, only two WSI platforms have received FDA approval for primary histopathological diagnosis in the United States. The Philips Intellisite Digital Pathology Solution received approval in 2017 for primary diagnosis of formalin-fixed paraffin-embedded (FFPE) tissues. This system cannot be currently used for frozen sections, cytology, or non-FFPE hematopathology specimens [49]. This closed system includes a digital scanner, image management software, and a display. In 2020, Leica Biosystem's AT2DX scanner received FDA approval in conjunction with Sectra's Digital

Pathology Software Module [50]. Keep in mind, the FDA regulates the manufactured device and not the medical professional's use of the device. Several professional pathology organizations have published guidelines for the technical specifications recommended for the implementation of digital pathologies, such as the College of American Pathologists (CAP) [51], the Digital Pathology Association [52], the Canadian Association of Pathologists [53], the European Union [54], the Royal College of Pathologists [55], and the Professional Association of German Pathologists [14].

One historical limitation for the incorporation of digital pathology into routine laboratory workflows was the restriction of CLIA'88 on "remote sign-out" of cases, where electronic verification of laboratory test results by qualified personnel under CLIA must be performed in the main laboratory. Remote sign-out of cases (e.g., pathologist's home or a hotel) required these remote locations to have separate CLIA licenses, complicating billing practices for professional services. However, due to the COVID-19 pandemic, CMS has temporarily waived this requirement for remote locations to have separate CLIA licenses provided that the designated primary site or primary laboratory has a Clinical Laboratory Improvement Amendments (CLIA) certificate [56]. Anatomic pathologists can now remotely sign-out cases with a microscope and glass slides or utilize a digital system validated by the laboratory, as long as these diagnostic activities are compliant with validated Standard Operating Procedures (SOPs) for remote work as approved by individual Laboratory Medical Directors [57]. Whether the CLIA'88 requirements for remote work will be reinstated remains to be determined.

Beginning January 2023, CMS will release 13 new Category III add-on codes for digital pathology. These CPT codes should be used to report additional staff service work required for slide digitization. This represents a major advancement for the incorporation of WSI into routine anatomic pathology workflow for primary diagnosis. These codes are not to be used for post-diagnostic archival digitization. While Category III codes currently do not provide national pricing from the Centers of Medicare and Medicaid Services, they usually receive hospital outpatient payment levels (APCs). The AMA CPT will also add a new heading in the Category III section and guidelines to define digital pathology digitization procedures. Consolidated listings of priced Category III codes are usually available on MAC contractors' websites.

The new codes are listed below, with the following descriptors [58]:

- **0751T**—Digitization of glass microscope slides for Level II, surgical pathology, gross and microscopic examination (List separately in addition to code for primary procedure) (Use 0751T in conjunction with 88302).
- **0752T**—Digitization of glass microscope slides for Level III, surgical pathology, gross and microscopic examination (List separately in addition to code for primary procedure) (Use 0752T in conjunction with 88304)
- **0753T**—Digitization of glass microscope slides for Level IV, surgical pathology, gross and microscopic examination (List separately in addition to code for primary procedure) (Use 0753T in conjunction with 88305)
- **0754T**—Digitization of glass microscope slides for Level V, surgical pathology, gross and microscopic examination (List separately in addition to code for primary procedure) (Use 0754T in conjunction with 88307)
- **0755T**—Digitization of glass microscope slides for Level VI, surgical pathology, gross and microscopic examination (List separately in addition to code for primary procedure) (Use 0755T in conjunction with 88309)
- **0756T**—Digitization of glass microscope slides for special stain, including interpretation and report, group I, for microorganisms (e.g., acid-fast, methenamine silver) (List sep-

arately in addition to primary procedure) (Use 0756T in conjunction with 88312).

- **0757T**—Digitization of glass microscope slides for special stain, including interpretation and report, group II, all other (e.g., iron, trichrome), except stain for microorganisms, stains for enzymes constituents, or immunocytochemistry and immunohistochemistry (List separately in addition to code for primary procedure) (Use 0757T in conjunction with 88313)
- **0758T**—Digitization of glass microscope slides for special stain, including interpretation and report, histochemical stain on frozen tissue block (List separately in addition to primary procedure) (Use 0758T in conjunction with 88314)
- **0759T**—Digitization of glass microscope slides for special stain, including interpretation and report, group III, for enzymes constituents (List separately in addition to primary procedure) (Use 0759T in conjunction with 88319)
- **0760T**—Digitization of glass microscope slides for immunohistochemistry or immunocytochemistry, per specimen, initial single antibody stain procedure (List separately in addition to primary procedure) (Use 0760T in conjunction with 88342)
- **0761T**—Digitization of glass microscope slides for immunohistochemistry or immunocytochemistry, per specimen, each additional single antibody stain procedure (List separately in addition to primary procedure) (Use 0761T in conjunction with 88341)
- **0762T**—Digitization of glass microscope slides for immunohistochemistry or immunocytochemistry, per specimen, each multiplex antibody stain procedure (List separately in addition to primary procedure) (Use 0762T in conjunction with 88344)
- **0763T**—Digitization of glass microscope slides for morphometric analysis, tumor immunohistochemistry (e.g., Her-2/neu, ER, PR), quantitative or semiquantitative, per specimen, each additional single antibody stain procedure, manual (List separately in addition to primary procedure) (Use 0763T in conjunction with 88360).

Summary

Teledermatopathology has become an integral part of the practice of dermatopathology. There are a variety of available systems and comprehensive billing codes which in addition to robust regulatory oversight ensure it can be applied safely to routine practice. Cost remains a key barrier to care but advances in *technology* will cause the costs to continue to fall while also paving the way for exciting new applications.

Conflicts of Interest There are no conflicts.

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18 Artificial Intelligence and Teledermatology

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Introduction

The expansion of artificial intelligence (AI) has the potential to transform healthcare. Augmented intelligence (AuI) is defined as "a concept that focuses on artificial intelligence's (AI) assistive role" by the American Academy of Dermatology, and is anticipated to assist in bringing increased precision to diagnostics, treatment standardization, and access to care. Applicable to both clinical and histopathological images, AI is potentially a powerful tool for augmenting care delivery via teledermatology, and advances in AI applications to dermatology are anticipated to be readily applied to teledermatology. During the COVID-19 pandemic, teledermatology became one of the most practiced forms of digital healthcare on the global scale [1] and transformed the concept of AI in telemedicine into an acceptable reality. Multiple models have been developed that use mobile device images to assess skin lesions. These models have the potential to expand healthcare access, ensure timely diagnosis, and reduce costs [2]. Dermatologist-level accuracy has been compellingly demonstrated in experimental conditions [3–6]; however, in real-world practice AI has shown limitations when compared to individual dermatologists [7–9] and was shown to be inferior when compared with collective decision-making by multiple dermatologists [10].

Many computer vision models have been developed for the assessment of skin lesions. While early AI models focused exclusively on skin cancer, recent models have been applied to several skin disorders, including melanoma [11–15], nonmelanoma skin cancer [13, 16], rosacea [17], vitiligo [18], psoriasis and eczema/atopic dermatitis [19–22], acne vulgaris [23], onychomycosis [24–26], erythema migrans [27, 28], herpes zoster [29], cutaneous lupus [30], alopecia areata [31], and pressure ulcers [32]. Many models can now identify up to 174 disease classes [7,

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8, 33–36]. Other AI model capabilities include the ability to analyze clinical data in addition to images [34, 37–41], classify multiple lesions from one wide-field image [16, 42, 43], and train on whole slide images without costly manual annotations on individual pixels [44]. However, models have still fallen short in addressing dermatologic diseases that are most common in clinical practice, such as inflammatory dermatoses and pigmentary issues [45]. Additionally, the robustness of existing models and obstacles to their clinical use has been assessed in multiple studies [3, 46, 47].

Despite the development of multiple models, and the approval of artificial intelligence/machine learning-enabled devices in several medical fields, the US Food and Drug Administration (FDA) has yet to approve any AI-based medical devices in dermatology [48, 49]. In Europe, one AI system (FotoFinder Moleanalyzer Pro™, FotoFinder, USA) using dermoscopic images has been market-approved with dermatologist-level accuracy in a store-and-forward teledermatology [12] and prospective clinic setting [50]. Additionally, the CE (Conformit Europenne) certification has been given for multiple patient-directed applications that use mobile images to aid in diagnosis [34, 51]. However, little data has been published to support their use [52].

In this chapter, we provide an overview of the current state of AI in dermatology and look at future prospects for AI in healthcare.

Applications

Diagnosis

AI models can be used to aid dermatologists in clinical practice and augment their diagnostic capabilities, for both teledermatology referrals [34] and face-to-face visits [53]. Although current AI falls short in real-world practice when used alone, dermatologists can benefit from using AI models in addition to their own diagnostic capabilities. While AI may be better at evaluating ambiguous images, humans are unlikely to be misled by the inferior image quality, such as blurriness or shadows [33]. Additionally, primary care physicians and other non-specialist providers can benefit from AI in the diagnosis of skin diseases [54] and patient triage for referral to dermatology. Referring clinicians can use clinical decision support tools embedded in the electronic health record (EHR) to decrease dermatology referrals and assist with treatment initiation [55].

In dermatopathology, the increased use of digital whole slide imaging [56] allows AI models to support dermatopathologists in the diagnosis of skin cancers. Many AI models have been established for the automated diagnosis of melanoma [39, 57–63]. However, only two models have performed on par with dermatopathologists in experimental settings [57, 60], and they might not be applicable to clinical practice as these models are limited due to the evaluation of only a partial [57] or single [60] hematoxylin and eosin (H&E)-stained slide compared to clinical practice where dermatopathologists can request further immunohistochemistry staining or clinical information. Adding basic patient information (age, sex, or anatomical site of the lesion) to convolutional neural network (CNN) training does not seem to improve performance [39].

Treatment Recommendation

AI models also have the ability to make basic clinical management recommendations based on images. For example, models are capable of predicting whether a lesion should be excised [64] or whether a patient needs treatment with a steroid, antibiotic, antifungal, or antiviral [33]. AI can also aid in evaluating drug interactions and responsiveness to treatment [65, 66]. In the primary care setting, providers can also use AI to initiate initial therapy after diagnosis of dermatological disease. However, these models are not yet able to select treatments that are unique to each patient's personal preferences and circumstances and therefore cannot replace dermatologists' consultation at this time.

Response to treatment and disease progression can also be assessed by AI models. Such models have the potential to evaluate and monitor disease severity and assist dermatologists in treatment management. Several models have been developed for automated assessment of alopecia [31], eczema [67], nevi [43], hidradenitis suppurativa [66], and psoriasis [68, 69]. While these models are still in their infancy, they offer a more objective alternative to current clinical assessment tools that have imperfect inter- and intra-rater reliability [68]. For disease progression, AI has the potential to predict the probability that a benign lesion will progress to malignancy. While no such model exists, prospective datasets that consider lesion evolution are currently being developed [70].

Outcome Prediction

In addition to image-based applications, AI can be used to predict the likelihood of disease development [71]. While the US Preventative Services Task Force determined that current evidence for visual skin cancer screening is insufficient to assess the balance of benefits and harms [72] new Australian guidelines recommend screening patients at highest risk [73]. Several AI models have been developed to predict patients' risk of developing melanoma [74–77] or nonmelanoma skin cancer [77–81] based on EHR data such as patient information and/or genetics. These risk prediction models have the potential to identify high-risk patients to facilitate targeted skin cancer screening programs. However, the clinical usefulness of such models is unknown as studies have substantial heterogeneity of risk factors, low consistency in model evaluation, and poor validation [82]. Additionally, many key factors in assessing skin cancer risk, including UV light exposure and family history, are not included in EHR systems, which may cause decreased model performance [78].

AI has also been used to predict dermatological outcomes outside of skin cancer. For patients with psoriasis, AI models have been used to predict response to biological therapy [83]. Additionally, they can predict the risk of developing psoriatic arthritis based on 200 genetic markers. These models have achieved greater than 90% precision among the top 5% of predictions for psoriatic arthritis [84, 85]. AI can be used to predict the prognosis of atopic dermatitis in children [86].

Image Quality

The accuracy of teledermatology depends in large part on the quality of the captured images. Images can be suboptimal in a number of ways: poor lighting or focus, alterations in color, suboptimal angle or framing, distracting or occluding objects, and low resolution. Image quality may especially matter for AI-augmented teledermatology since AI can be influenced by artifacts such as scale bars [87], and surgical skin markings [88] that humans can readily ignore. Standard and practical protocols for image capture are needed to maximize the performance and reliability of AI-augmented teledermatology. Image quality can influence the accuracy of teledermatology diagnosis relative to in-person diagnosis. In a randomized clinical trial of 40 patient-parent dyads, patient-submitted images were of generally sufficient quality for accurate teledermatology diagnosis of pediatric skin conditions compared to in-person diagnosis, but concordance was lower across all images (83%) compared to the subset of images considered to be of sufficient quality (89%) [89]. Additionally, image quality affects AI model accuracy. In a study of three AI models trained to classify malignant vs benign lesions, the accuracy and sensitivity of the AI models decreased as image quality decreased (due to blur or changes in brightness) [47].

While the importance of image quality is well-established, it is challenging to reliably capture high-quality images in a busy clinical setting. Lack of time, training, proper imaging equipment and setup, and other resources are potential barriers. To guide the collection of high-quality images, technique standards for skin lesion imaging have been proposed [90], including recommendations on lighting, background color, field of view, image orientation, and color calibration. Standardized photographic documentation protocols have also been proposed for specific diseases such as vitiligo [91] and hidradenitis suppurativa [92].

Improving image quality will require a multipronged approach. Patient education via “4 Key Instructions” (Framing—asking the patient to take at least one image up close and one further away; Flash—educating the patient that a flash can help produce a sharper image, but not to use too close; Focus—asking them to allow time for the camera to engage in auto-focus; Scale—encouraging the use of a ruler or a coin to help determine size) and an information leaflet increased the quality of photos submitted in a primary care setting in the UK [93]. Photography education may also help to increase the quality of photos taken by dermatology residents [94]. Methods to automatically assess image quality and provide immediate feedback to users to make adjustments and retry are promising, but they are still nascent. In a review of 191 digital skin imaging applications, just over half (57%) included one or more image acquisition technique features (e.g., imaging tips, multiple image requirement, blur/focus detection) to improve image quality, and very few included Image quality Artificial intelligence (AI) image quality more than one [95].

Mobile AI for Teledermatology

The widespread use of smartphones facilitates the direct use of AI applications by patients for screening or monitoring. AI models can run on smartphones, preserving privacy by keeping health information from leaving one’s personal device [96]. Proof of concept for automated smartphone risk assessment has been established: an AI model trained on patient smartphone-generated images performed comparably to general practitioners for classifying whether pigmented lesions are at lower vs higher risk [38]. Another model has increased the sensitivity of malignancy diagnosis of 23 non-medical professionals from 47.6% to 87.5% without a loss in specificity [33]. However, no currently available smartphone apps intended for use by laypersons to assess skin lesions have demonstrated sufficient performance or generalizability to recommend their use [97]. Of note, the CE (Conformit Europenne) certification, given to two flawed apps (SkinVision and TeleSkin’s skinScan app) may be inadequate to protect users from the risks of using smartphone diagnostic apps; in contrast, the FDA has a stricter assessment process [98].

Apart from screening, AI may also facilitate monitoring, for example, in evaluating lesion change over time [99]. AI may work synergistically with applications designed for self-examination and documentation of moles [100, 101]. AI may also aid in cosmetic evaluation, as from user-taken selfies [102].

VisualDx™ (VisualDx, USA), a currently available mobile app, allows healthcare providers to search an image library of skin conditions by inputting clinical features or by taking a photo of the skin lesion or rash (available with the DermExpert add-on) [103]. However, while it is gaining wider usage, no data has been published to support the benefit of its use.

Clinical Validation

Clinical validation is the process of determining the performance of a model or instrument when used to provide diagnosis and guide management for actual patients in the clinic [104]. Typically, clinical validation for AI-augmented teledermatology is performed with a panel of board-certified dermatologists reviewing images and providing ground truth for diagnosis, against which the AI is measured. Such real-world validation is important because though many models perform similarly to dermatologists in carefully selected datasets that exclude low-quality images, they may not perform as well in a real-world scenario. In everyday use, teledermatology cases consist of images of varying quality (i.e., those taken with poor lighting, those which are out of focus, or those which are taken at a non-ideal camera angle or distance), and training datasets typically exclude such images [3]. Even when photos of high quality are used to challenge an algorithm, AI can stumble when the zoom, brightness, or contrast of a test photo is different from the photos used to train the algorithm. This potential pitfall was illustrated when an algorithm designed to distinguish benign skin lesions from skin cancer [24] which had been trained using the Asan (Korea) and Med-Node (the Netherlands) datasets was tested using images from the International Skin Imaging Collaboration Archive and yielded significantly less accurate results [105]. In one test case, an image of a typical basal cell on a background of solar lentigines yielded a final diagnosis of lentigo with 99.2% accuracy, perhaps because the algorithm had been trained on more closely cropped or zoomed-in photos of basal cell carcinomas [105]. A subsequent retrospective validation study involving this algorithm and local clinicians showed that using appropriately selected images, the algorithm could achieve accuracy to a dermatologist reviewing the images without clinical history, though both were inferior to the prediction of the dermatologist performing the clinical exam and biopsy [7]. In a test of another algorithm, which had been trained with a dataset in which lesions that were ultimately biopsied were marked with a purple skin marker, images of benign nevi that had been marked with a purple marker were 40% more likely to be rated as melanoma [88], again emphasizing the need for real-world validation prior to clinical use.

In contrast to prior work, some recent research on AI-augmented teledermatology has incorporated clinical validation into the study design. Clinical validation was performed in a study involving 19,870 real-world cases from a teledermatology practice, 9 dermatologists, 6 nurse practitioners, and 6 primary care physicians [34]. A rotating panel of three dermatologists was used to set the reference standard, and the accuracy of a deep learning model was measured against the reference standard, the remaining dermatologists, the nurse practitioners, and the primary care physicians. The deep learning model arrived at the favored diagnosis of the reference standard in 66% of cases, which was non-inferior to dermatologists (63%), superior to primary care physicians (44%), and superior to nurse practitioners (40%) [34]. Lighting and camera angles were not highly standardized and skin markings were generally not used in the training or validation photo sets, potentially contributing to the external validity of this study.

Clinical validation of AI is a crucial step in identifying pitfalls, particularly blind spots and limits to the generalizability of algorithms. Unfortunately, it is not consistently performed as part of research on AI in dermatology. Many studies of AI in teledermatology use highly standardized "test sets" to establish the accuracy of algorithms [4–6, 106], and while this is a useful first step, the use of standardized test sets or use of ultimate pathology diagnosis as a "gold standard" can limit the real-world applicability of results and potentially overestimate the accuracy of algorithms, as illustrated by the above examples. Robust clinical validation of AI in teledermatology should be a priority, especially as the sophistication and range of diagnoses covered by algorithms increases.

Conclusion

AI will have a major impact on dermatology in the coming years and must be implemented with rigorous quality checks to reduce the risk of harm. The American Academy of Dermatology (AAD) has released a position statement on what is termed augmented intelligence, AuI, to guide clinical implementation [107]. In this statement, the AAD emphasized the need to have high quality and minimally biased training sets, early engagement and collaboration of stakeholders, and maximal transparency regarding AuI models' decision-making and data. Importantly, models need to be trained on datasets representing diverse skin tones, since otherwise performance falls when tested on darker skin tones [108].

Careful validation of AI models is essential prior to their clinical use. Existing models should be vetted using computational "stress tests" to ensure adequate performance in real-world settings [3]. Models should be tested for their robustness to differences in image quality and transformations such as image rotation, brightness and contrast manipulation, adversarial noise, and artifacts such as ink markings and rulers [3, 87, 88, 109–111]. An advantage of convolutional neural networks is their ability to automatically determine the most relevant features of an image for classification. However, a disadvantage is that the convolutional neural network training can introduce unexpected biases, for example, in learning an association between melanoma and surgical skin markings [88] or scale bars [87]. Modeling uncertainties may help users assess when models are more likely to be wrong [112], and more interpretable neural networks may help pinpoint what information they rely on to make decisions [113].

The recent growth in teledermatology programs provides ample opportunity for the development of AI models for diagnosis, treatment recommendation, and outcome prediction. AI models that utilize deep learning have the potential to achieve results similar to face-to-face care; however, these technologies fall short in clinical practice due to several barriers and limitations. As teledermatology use increases, research in AI needs to refine deep learning methods in order to achieve results on par with clinical practice.

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19 Teledermatology: Research Utilization

Neda Shahriari and Joseph F. Merola

Introduction

Telemedicine has become a transformative technologic force in health care by seeking to provide access to patients with socioeconomic, physical, and geographic barriers [1]. Prior to the COVID-19 pandemic, much effort was concentrated on the expansion of health care to rural areas through telemedicine with varying results [2, 3]. However, the COVID-19 pandemic with its need for social distancing engendered a crisis of access to health care for *all* patients regardless of geographic and financial backgrounds, and facilitated rapid expansion to replace in-person visits [4]. Some studies have recently demonstrated the cost-saving benefits, convenience, high diagnostic concordance rates, and overall high satisfaction rates with telemedicine further promoting its use [5–9]. This was also demonstrated in the setting of teledermatology, specifically [10]. Although the focus of telemedicine has been patient care access, another important area for the potential use of digital health technology is clinical research. During the pandemic, a gap that presented itself was the lack of streamlined protocols in place for carrying out remote clinical trial appointment visits, which are important for the delivery of medication, tracking patient progress, and serving the overarching goal of treatment expansion. We will discuss suggestions for the use of teledermatology in the research setting.

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Application of Teledermatology to Clinical Research

Although teledermatology has been more widely adopted as a tool to conduct medical visits, it is emerging as a promising tool for conducting clinical research including clinical trials. The traditional dermatology clinical trial involves a centralized medical facility where patients have regular visits to track progress and also to store and maintain relevant data. The traditional model is time-consuming, requiring at least 10 years for a drug to come to fruition, and costly with an average that exceeds $2.6 billion [11, 12].

With the more widespread use of technology, it is possible to have part or conceivably all of the trial visits conducted virtually. The concept of a

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virtual clinical trial, or decentralized clinical trial (DCT), has been previously discussed and would take place in the patient's home and managed by a coordination center or, referred to by some as, a site-less clinical research organization (CRO) [11]. The site-less CROs can use digital health technologies for different activities including recruitment, education, screening, informed consent, and data collection [11]. In a hybridization model, asynchronous visits—utilization of store-and-forward technologies—and synchronous visits—live, real-time use of virtual technologies—can be concomitantly employed as per the trial protocols [13, 14]. Overall, these measures can be beneficial in increasing convenience for patients by decreasing the burden of in-person visits and the need to travel, allowing expansion to those who lack geographic access and accelerating research endeavors [15]. This can also especially benefit patients who are older and/or have complex diseases where in-person visits are nearly impossible, as well as if the length of the study is long yielding a cumbersome commitment for patients [11].

Established Virtual Dermatology Clinical Trials

Although slower to expand, virtual clinical trials have been gaining momentum recently. In the field of dermatology, few studies have been conducted virtually either completely or utilizing a hybrid model. The PHEMPHIX trial, which compared the efficacy of mycophenolate mofetil versus rituximab in the treatment of pemphigus vulgaris, utilized a hybrid model where patients communicated with the research team through smartphone apps, mobile nurses, telemedicine visits with few in-person clinical visits [15, 16]. Interestingly, with this model, they were able to recruit patients more rapidly in comparison to the traditional model, which can be quite beneficial in the case of rare diseases where recruitment can be challenging [15]. The phase 2b AOBiome trial, evaluating the efficacy of ammonia oxidizing bacteria for the treatment of acne vulgaris, was entirely virtual and utilized photographs obtained by the patient and uploaded onto relevant iPhone application to evaluate progress [15].

Logistics

Initial Setup

The COVID-19 pandemic stimulated innovative means for patient assessment and follow-up for clinical research through the expansion of digital health technologies. Out of this necessity, many local sites developed and implemented standard operating procedures (SOPs) that outlined and permitted the use of a variety of maneuvers to allow virtual visit assessments, remote monitoring oversight, and investigational product (IP) shipment to subjects, among other functions. As previously mentioned, models for the incorporation of virtual technologies in clinical research can focus on partial or full involvement in the workflow.

Telemedicine state licensure requirements dictate that medical practitioners must hold a state license where the trial participant is receiving treatment [17]. Therefore, it is suggested for those DCTs occurring across multiple states to institute investigators in each state or work with providers who have licensures in multiple states [17].

In advance of the virtual appointments, staff should work with patients to facilitate technologic setup and education on the use of equipment for their telehealth visits. As per guidelines, all video communication products must be HIPPA compliant according to the Office for Civil Rights (OCR) at the Department of Health and Human Services (HHS) [18]. Table 19.1 lists vendors that provide HIPAA-compliant video communication products.

A previsit screening can be performed by one of the clinical researchers to check in with the patient regarding any issues with the study. Questionnaires relevant to patient-reported outcome measures—e.g., patient's global assessment, physical function, work impairment, pruritus, and health-related quality of life—can be provided to patients ahead of time for comple-

Table 19.1 Vendors with HIPPA compliant video communication products [18]

Vendors
Skype for business/Microsoft teams
Updox
Vsee
Zoom for healthcare
Doxy.Me
Google G suite hangouts meet
Cisco Webex meetings/Webex teams
Amazon chime
GoToMeeting
Spruce health care messenger

tion prior to the appointment. This removes the time-pressure patients experience during an in-person trial visit to rush and complete self-assessments. The use of web-based surveys or e-surveys to increase the speed and accuracy of data collection has also been previously discussed [19].

Clinical Trial Teledermatology Visit

On the actual appointment day, the provider can spend time working on the subjective and objective parts of the patient assessment. The subjective assessment of the visit should not be difficult to complete as pointed questions can be easily addressed to the patient with documentation through the digital health platform [20]. A psychiatric evaluation is typically included as part of the research protocol which can be easily performed virtually.

Objective Assessment

Assessment of objective measures can be more challenging and depends on the DCT model. In-person home visits can be integrated to bridge the gap in collection of vitals, biospecimens, and other biometrics by trained personnel. This method maintains the benefits of removing the travel requirements for subjects. Furthermore, there should also be an established standard approach to the completion of the physical exam involving video communication products [21]. Recent guidelines have become available for virtual hair and scalp examinations [22] as well as patient-assisted virtual physical examination of all organ systems including the skin [23]. The physical examination is a key objective measure for evaluating skin improvement to ultimately ascertain whether the study drug is efficacious. Given the challenges posed by the inability to evaluate the patient in-person, remotely this portion requires a joint effort from the patient and clinician. That is, the clinician should visually evaluate the affected parts of the body that are accessible on video in combination with the patient's self-examination of areas that the clinician is unable to assess personally on video [20]. For example, the genitals and scalp require direct questioning about disease involvement as it is difficult to observe on video [20].

In addition to video evaluation, another method for evaluation and documentation of the physical exam is the use of store-and-forward images that capture different areas of the patient's body. This allows the clinician to then thoroughly evaluate the images to accurately document affected areas on the physical exam. One study found that the lesion count and the Investigator's Global Assessment derived from patient-captured photographs of acne utilizing Network Oriented Research Assistant (NORA) was similar to in-person examination—intraclass correlation coefficient of 0.81 and 0.75, respectively [24].

In the case of patient involvement for characterizing disease, body surface area (BSA) of involvement can be assessed using the "palm rule" through a combination of physician remote assessment and patient self-evaluation [25]. Other objective measures can be similarly obtained with the assistance of the patients. For example, in the case of psoriasis, the Psoriasis Area and Severity Index (PASI) is a component of the standard assessment for clinical trials performed by the evaluator [26, 27]. However, studies have shown that self-administered PASI is valid and reliable and can be used for "at-distance" follow-up [28–31]. In one study, patient self-administered PASI scores were compared to clinician-established PASI scores. The self-administered PASI consists of a silhouette of the front and back of the body and requires the patient to shade in areas of involvement with psoriasis [28]. A visual analog scale is present for erythema, induration, and scaliness for the patient to rate their lesions and ultimately, the final score of the self-administered PASI is between 0 and 72 similar to the traditional PASI [28]. Ultimately this study, similar to its predecessors, showed a high correlation between the self-administered PASI and traditional dermatologist-evaluated PASI confirming the potential for predictability of disease response (Pearson correlation coefficient, $r = 0.69$) [28]. It was noted however that the self-administered PASI was higher on average in comparison to PASI thought to reflect patient's overestimation of their condition [28]. Of note, eClinicalHealth recently announced the creation of a digitized self-administered PASI application—Clinpal (United Kingdom)—to more easily allow for patients to denote disease severity and quality on the digital body map, which is in an effort for decentralization of clinical trials to achieve faster outcome results [32].

Other self-assessment tools have been found to be correlated with the traditional dermatologists' evaluation [33]. Table 19.2 depicts a summary of available self-administered assessment tools for common dermatologic clinical trials. These tools can be particularly useful in the setting of a teledermatology clinical trial visit for the derivation of objective assessment of patient progress. In the current era of telemedicine, it is important to expand and further test self-assessment tools, especially for dermatologic diseases that currently lack available self-measurements, to enable the viability and expansion of telemedicine clinical research.

With regards to patient perspective on the use of digital health technologies, studies have shown positive responses for its incorporation into clinical research, including increased direct engagement of patients in the process [34]. One study evaluating the use of mobile technology for the collection of patient data in clinical trials found

Table 19.2 Screening tools utilized in common dermatologic clinical trials research alongside more recently developed self-administered assessment tools for objective measurement of patient progress remotely

Screening tool	Traditional assessment	Self-administered assessment
Psoriasis area and severity index (PASI)	• Evaluation of involvement per BSA according to following regions (0–6): Head, arms, trunk, and legs • Evaluation of intensity (0–4): Erythema (redness), induration (thickness), and desquamation (scaling) [38] • Scores ultimately from 0 to 72	• Silhouette of the front and back of the body provided to the patient to shade in areas of impact • Visual analog scale for erythema, induration, and scaliness • Scores ultimately between 0 and 72
Eczema area and severity index (EASI)	• Evaluation of involvement per region (0–6): Head/neck, upper limbs, trunk, lower limbs • Evaluation of intensity (0–3): Erythema, infiltration/papulation, excoriation, Lichenification [39, 40]	• Line-drawing silhouette of the front and back of the body provided and patient shades in areas of impact by atopic dermatitis • Evaluation of involvement per region (0–6): Head/neck, upper limbs, trunk, lower limbs • Five modified 100-mm visual analog scales: Redness, thickness, dryness, scratches, and itchiness of "average" eczema lesion [33]

(continued)

Table 19.2 (continued)

Screening tool	Traditional assessment	Self-administered assessment
Hurley stage	Defined by three stages [41]: • I: Abscesses present but no sinus tracts or cicatrization • II: Recurrent abscesses with tract formation and cicatrization • III: Diffuse involvement of multiple interconnected tracts and abscesses	• Ten photographs of different Hurley stages provided to the patient (patients completed self-assessment 30 min after the first completion to assess retest reliability) [42]

that patients preferred clinical trials with mobile technology in comparison to the traditional trial model [35]. According to this study, patient found the incorporation of mobile technology to decrease the burden of the research study by reducing in-person clinical visits and increasing data accuracy [35].

Limitations

Although remote clinical trials have widespread beneficial implications with high patient satisfaction rates, some barriers exist to its full expansion. Limitations include lack of technologic proficiency for certain populations including the elderly, Internet connectivity issues, as well as limited access to technologic tools which may occur among those with lower socioeconomic status [20]. Transmission of patient data and photographs electronically may also be of lower quality given the lack of training and may be uncomfortable for patients if involving sensitive body locations [15]. On the provider side, the training required for physicians and the research team must be taken into consideration as well as the challenges of attaining objective outcome measures virtually. Coordination of patient receipt of medication—depending on whether it is injectable, infused, or oral—also adds another level of complexity. Particularly for pivotal trials, DCTs may pose some regulatory concerns regarding data quality on the part of both sponsors and regulatory agencies which still remains to be addressed. Overall, the placement of streamlined, standardized protocols can abate some of these issues.

Future Directions

There is avid research in the field of sensor technology, which can further supply vital objective data in remote clinical trials to better inform disease progress. As an example, smartphone wearable sensor tools have been developed for psoriatic arthritis that enables tracking of range of motion to provide more objective patient outcome measures to be used remotely [20, 36]. Specific applications to the field of dermatology include atopic dermatitis sleep sensors which are being established to track patients' pruritus levels through the night [37]. Overall, we are headed into an era of data supplementation of disease progress through technologic expansion.

Conclusion

Teledermatology was previously an area of slow growth mainly reserved for patients with geographic and socioeconomic barriers. Following the COVID-19 pandemic, the need for teledermatology access for all patients hastened a swift response leading to quick expansion. Although the focus has been more on medical visits, there is increased investment in establishing available protocols for remote clinical trials as well.

Beyond the pandemic, there are barriers to enrollment in clinical trials for patients including the inconveniences of multiple visits with the associated burden of travel. Circumventing some of these barriers by enabling fully virtual clinical trial visits or hybrid visit models can increase enrollment, reduce cost, and save time. Furthermore, allowing an expansion of access to those who are remotely located geographically can increase enrollment for rare diseases where recruitment would take several years. Therefore, not only can adoption and implementation of DCTs be beneficial to patients by removing cumbersome aspects, but it can also cast a wider net of participant inclusion, push the boundaries of research further and provide access to underserved populations.

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20 Teledermatology: Patient and Provider Satisfaction

Maham Ahmad and Sara Perkins

Introduction

Satisfaction is a broad term for an inherently personal and nuanced concept. Yet, generally speaking and across the board, satisfaction with teledermatology is described as high. Competing interests and unique concerns among key stakeholders preclude simple answers. Further, factors such as the lack of standardization in research methods and questionnaire design, and heterogeneity among studied populations, make it difficult to generalize results.

For patients, convenience and expanded access certainly drive acceptance, and possibly preference, whereas privacy concerns and lack of comfort with digital images or technology are important limitations. For referring primary providers, facilitation of communication with or assistance from a specialist is welcomed and often educational. However, dermatologists, while also valuing expanded access, lament concerns over diagnostic accuracy and medicolegal liability. Overlying these myriads and sometimes competing interests is variation in study approach and methodology.

Herein we examine the broad issue of satisfaction with teledermatology in further detail, noting important variations among populations and settings, to better understand what this may tell us about its future use.

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Defining and Measuring Satisfaction

Study design within the patient satisfaction literature varies widely. Satisfaction has been analyzed among cohorts, cases, and controls, as well as retrospectively and prospectively. Definitions of satisfaction vary widely among individual studies. Extrapolating from the broader literature, Kraii et al. developed a definition of patient satisfaction that encompassed eight domains: interpersonal manner, technical quality, accessibility, financial burden, efficacy, continuity, physical environment, and availability [1]. Convenience, which likely includes components of accessibility and financial burden, may also be a significant driver of patient satisfaction. Corresponding critical domains for provider satisfaction have been less well-delineated, though at least partial overlap undoubtedly exists (Fig. 20.1).

Study instruments have also varied considerably. Many studies have utilized individually developed questionnaires, though some have incorporated surveys that have been previously published. The majority utilize a 5-point Likert scale (Fig. 20.2), though some have employed nominal scaling, qualitative, or written feedback

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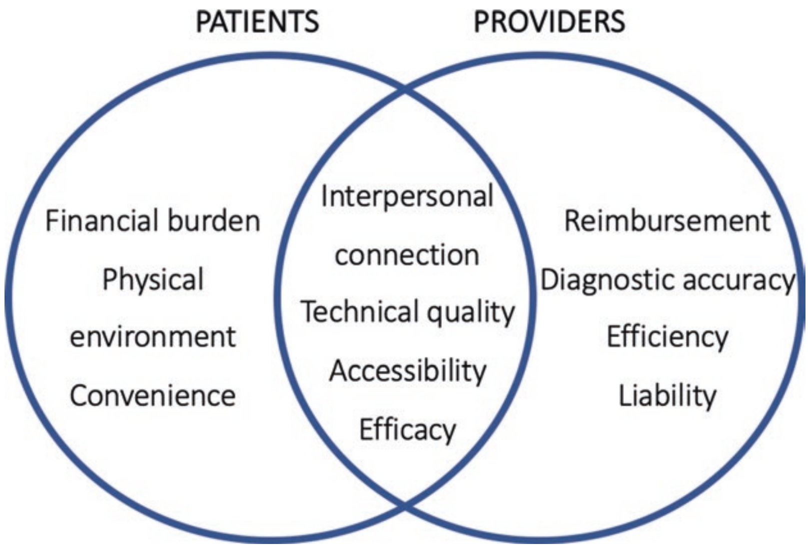

Fig. 20.1 Hypothesized domains of satisfaction among patients and providers

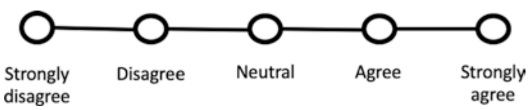

Fig. 20.2 5-point Likert scale utilized in many teledermatology satisfaction studies

[2–7]. Rare mention has generally been made of internal or external validation of utilized questionnaires, though some studies have specified attempts made to minimize the introduction of survey bias [8]. Moving forward, the refinement of domains of satisfaction for all stakeholders and the development of validated study tools will be critical.

Satisfaction Among Patients

Broadly speaking and throughout its use, patient satisfaction with teledermatology has been quite high. However, subtleties within study design and population reveal the diversity of potential applications, as well as some insights into potential drivers of satisfaction. A small majority of studies have assessed patients' satisfaction scores with the use of the store-and-forward modality of teledermatology. Comparatively fewer have assessed patient satisfaction with the live-interactive modality, though its use has significantly expanded since the COVID-19 pandemic [9, 10]. Finally, a smaller but growing number of studies have examined patient satisfaction with direct-to-consumer teledermatology programs [6]. It is reassuring that across all studies, satisfaction remains quite high.

Patients' reported satisfaction is undoubtedly multifactorial, personal, and complex. As in the general telemedicine and patient satisfaction literature, studies of patient satisfaction with teledermatology have attempted to assess various domains [1, 7]. Across the literature, the most heavily studied aspects of patient satisfaction in teledermatology have included accessibility, efficacy, technical quality, and physical environment [7]. Fewer studies have evaluated satisfaction within the interpersonal manner domain, an area where teledermatology may fall short. However, reassuringly, both patients and physicians rated the personal connection between them during the virtual encounter as favorable, with no significant difference in the overall score between the two groups [8].

While many teledermatology programs are broad in scope, others have focused on specific patient populations. Again, satisfaction among these population subsets remains high throughout. One such subset in which teledermatology has been utilized and studied in the United States is the Veteran population. Studies have shown that factors associated with higher satisfaction include shorter wait times, a belief that their conditions were properly treated and monitored, and receipt of educational materials from their providers [4]. One study found that a majority of veterans (58%) would not have been willing to go to the nearest Veterans Affairs location if teledermatology was not available, suggesting that accessibility and convenience may be key drivers of satisfaction in this subset of patients [11].

Teledermatology's expanded access and improved convenience might be particularly well-suited to pediatric dermatology as well. Access to these specialists is even more limited than in general dermatology, time away from school and work can be incredibly disruptive for patients and families and, comparatively, these patients are less likely to require in-office procedures. However, few studies have assessed patient satisfaction among the pediatric population. A prospective cohort study found that 83% of parents using a pediatric teledermatology consultation program were likely to recommend the service to others. Open-ended responses found that parents appreciated the aspects of convenience, timeliness, accuracy, and patient-centered care of teledermatology [12]. A younger patient and caregiver population may also be more technologically savvy. In a prospective study of a store-and-forward, direct-to-consumer teledermatology app at the Children's Hospital of Philadelphia, researchers found an overall satisfaction rate of 86%, with 88% of survey respondents reporting willingness to use the app again and the likelihood of recommending the app to family or friends [13].

It is important to note that while, generally speaking, patient satisfaction scores are high, there is significant variation within the literature. Satisfaction reports range between 42% and 100%, though this is likely, at least in part, due to the wide variability in assessments and definitions used in various studies [14]. Some studies have found that younger patients and patients with fewer medical comorbidities may be more satisfied with teledermatology [2]. Potential drivers of dissatisfaction are further discussed later in this chapter.

Satisfaction Among Providers

Providers, whether referring or consulting, are key stakeholders in any teledermatology program, and while they likely share many priorities with patients, they also have unique concerns. Provider satisfaction studies are somewhat fewer in number and generally assess fewer respondents than their patient satisfaction counterparts [10]. Studies have assessed satisfaction among a variety of provider groups, including primary care physicians, dermatologists, nurses, and technicians.

Generally speaking, studies have shown a high level of satisfaction with teledermatology among referring providers. One study reported that 95% of referring primary care providers (PCPs) were happy with the timeliness of store-and-forward teledermatology evaluation in an eConsult program [15]. Another study of general practitioners showed that 92% found the teledermatology program to be very useful or somewhat useful, and 89% indicated they were likely to use the system again [16]. As an additional and perhaps unintended benefit, many referring and general providers reported high levels of satisfaction with the educational benefit of teledermatology programs [17–20].

Another key driver of primary provider satisfaction is likely expanded access, and several studies have shown this by examining rural practice settings [21–23]. A study designed to assess satisfaction among primary care providers and imaging technicians (which included registered nurses, licensed practical nurses, and health technicians) found that both groups were satisfied with the ability to provide dermatology care in rural settings, the reliability of the equipment, and rapid process of consults, though imaging technicians reported higher levels of satisfaction in all categories than primary care providers [22]. Another study found that PCPs in rural practice settings were more satisfied with a teledermatology program than their urban counterparts, though satisfaction among both groups was high ($p < 0.001$) [24].

Compared to their referring colleagues, dermatologists' satisfaction with teledermatology has been less frequently studied, though this has changed in recent years. While surveyed dermatologists have generally reported high levels of satisfaction with teledermatology programs, rates tend to be lower than those of referring primary care providers [25, 26]. Dermatologists also tend to report less confidence in their diagnostic accuracy with teledermatology and often prefer in-person visits [27, 28]. Some studies have surveyed dermatologists' perception across a variety of satisfaction domains [29]. In one example, dermatologists preferring the store-and-forward modality based their rankings on efficiency, while those preferring live-interactive visits cited the ability to interact with patients. Among subsets of dermatology providers, studies have shown that pediatric dermatologists generally perceive teledermatology favorably and would like to incorporate it into their practice [30]. However, recent research involving dermatologists across practice settings has found that the vast majority utilized teledermatology during the COVID-19 pandemic, and most planned to continue or expand their use in the future [31].

Satisfaction Across Clinical Scenarios

While many have focused on a broad understanding and implementation of teledermatology, some advocates have proposed uses, narrower in scope, where teledermatology may be particularly beneficial. Examining satisfaction among subsets of complaints and practice settings may provide further insight into how best to utilize this technology. It is reassuring that satisfaction has remained high throughout.

In the authors' experience, the accuracy and reliability of evaluation of skin lesions generally, and pigmented lesions in particular, via teledermatology is an area of ongoing debate in both the medical literature and conversationally within the specialty, as discussed elsewhere in this book. However, several studies have looked specifically at patient and referring provider satisfaction with skin cancer screening and pigmented lesion teledermatology programs. One study examining a triage system for pigmented lesion evaluation found that 86% of patients, and 97% of referring general practitioners, were very satisfied with the service [32]. Others have shown the majority of patients would recommend a skin cancer or pigmented lesion teledermatology evaluation, felt confident in the service, and would be willing to pay out of pocket for the assessment [2, 33, 34]. Caution is advised when extrapolating some of these results as many studies incorporated the use of proprietary teledermoscopy technology or medical photographers.

Within the inpatient setting, in particular, expanded access appears to be a primary driver of satisfaction. Dhaduk et al. presented an inpatient teledermatology program in which 100% of patients accepted teledermatology consultation and 100% rated the experience as positive [35]. However, other studies have shown that physicians are only neutral to weakly positive on the utility of teledermatology in the inpatient setting and that teledermatology might be most useful for hospital follow-up visits for patients in whom comorbidities or distance traveled make in-person visits more challenging [36, 37].

Many providers have suggested that the follow-up of long-term patients with chronic issues might be the most ideal application for teledermatology. Telemonitoring of chronic wounds has demonstrated high acceptance among patients (70–80%), home care nurses (100%), and wound experts [38, 39]. Studies in acne patients demonstrate high patient satisfaction and suggest that nearly half of the patients prefer to continue with virtual visits rather than returning to in-person visits [40, 41]. Patients taking isotretinoin may be particularly well-served by teledermatology programs given the burden of visit requirements [42]. Other inflammatory skin diseases in which teledermatology programs have been highly accepted include hidradenitis suppurativa and psoriasis [43–45]. Finally, several studies have shown high rates of patient acceptance with virtual cosmetic consultation and post-procedure monitoring [46, 47]. Taken together, there is significant potential for teledermatology across the diversity of our specialty.

Satisfaction Around the Globe

Patient satisfaction with teledermatology has been broadly demonstrated, with studies originating in the US, Europe, the Middle East, Asia, Australia, and Africa [2–6, 9, 13, 29, 44–53]. Little is known about patient satisfaction and preferences in South America. These studies have encompassed live-interactive, store-and-forward, and direct-to-patient programs. Studies of provider satisfaction have encompassed similar geographic diversity though with comparatively fewer total studies and number of participants evaluated [15, 16, 18–20, 24–28, 54, 55]. Many of these studies examined satisfaction among referring general practitioners, with fewer numbers of consulting dermatologists' satisfaction being reported.

Dissatisfaction and Concerns

While the majority of satisfaction studies in teledermatology have demonstrated positive results, comparatively few have demonstrated dissatisfaction. In addition, studies noting overall high satisfaction have also raised and evaluated various concerns among key stakeholders. Taken together, these undoubtedly offer insights for improvements and optimization while simultaneously serving as important words of caution for teledermatology's expanding utilization.

Providers

While perception may or may not mirror reality, physician confidence in teledermatology may be one of its most significant barriers. Concerns over diagnostic accuracy seem to be a primary driver of this, despite a growing body of evidence to the contrary, with missed diagnoses being particularly worrisome [56–60]. One study suggested both referring clinicians and consulting dermatologists may lack confidence in teledermatology evaluation and its diagnostic accuracy [61]. The extent to which medicolegal liability may be a driver of these concerns is largely unknown, though a role has been suggested [62].

Further, in a study evaluating sources of psychological distress during the COVID-19 pandemic, Bhargava et al. found that teledermatology use was associated with the largest increase in the odds ratio for mental distress among surveyed practicing dermatologists [63]. While likely multifactorial, including lack of familiarity with, or preparedness for, teledermatology, the potential for a negative impact on quality of life must be addressed and ameliorated. However, expanded use of, and increased exposure to, teledermatology may improve physician comfort and decrease distress. In a pre-pandemic study among trainees in the UK, authors found that only 15% of respondents slightly agreed, and no respondents strongly agreed, with feeling confident in their teledermatology skills [64]. In a follow-up survey 6 months into the pandemic, dramatic improvements were seen, with 68% of trainees feeling slightly or strongly confident in their skills [65]. This underscores the importance of continued evaluation of satisfaction over time.

Patients

When asked to evaluate their teledermatology experiences, patients, too, have raised important concerns. While simultaneously noting high levels of satisfaction with a teledermatology service, one study found that nearly 69% of patients indicated preference for an in-person visit for their next appointment [66]. It is worth noting here that, compared with satisfaction, the notion of preference for virtual versus in-person visits has been examined with much more inconsistent results, emphasizing the inherent nuances in behavioral science [67].

Many authors have highlighted concerns over privacy, security, or comfort with photographing or recording ones' skin. While some have pointed to the technical challenges of capturing the images—positioning, lighting, Internet connectivity—others have highlighted a sense of vulnerability or cultural sensitivity. One study in Saudi Arabia found that 23% of participants refused photography, citing social or religious concerns [68]. In a study employing a medical photographer, some patients noted the process of being photographed as "uncomfortable" and the sending of photographs as "embarrassing" [11]. This has been corroborated by others showing a small but significant portion of patients feeling uncomfortable or embarrassed [2, 69]. This is particularly important in conditions that tend to involve more sensitive areas of the body. In a study of patients with hidradenitis, 42% reported not feeling safe sharing required photos or videos, with the majority of this group citing privacy concerns as their rationale [43].

Finally, patient dissatisfaction with teledermatology increases as the quality of life decreases, and several studies have shown that medical comorbidities, complexity, and age inversely correlate with satisfaction with or preference for telemedicine [69].

Conclusion

For more than two decades, patients and providers have demonstrated high levels of satisfaction with teledermatology. It has been perceived as positive or beneficial across various domains in myriad patient populations and clinical scenarios, emphasizing the vast potential applications of this care modality. However, research in this area would benefit from the standardization of satisfaction domains across key stakeholders, and the development and validation of standardized questionnaires. Finally, important concerns have been raised regarding perceived diagnostic reliability and privacy, which must be addressed for future optimized use.

Conflict of Interest None.

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21 Teledermatology: Resident Education/Conferencing

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Introduction

The University of Pittsburgh Experience:

The rise of teledermatology has translated into opportunities for virtual learning experiences in both graduate and undergraduate medical education. Virtual learning experiences crafted specifically for dermatology residents represent accessible supplements to an existing core residency curriculum.

Due to the COVID-19 pandemic, the majority of resident lectures have been given through a virtual format. At the University of Pittsburgh Medical Center, we have 4–5 h of protected didactic time for residents to learn material covered in dermatology textbooks. As part of the predominantly virtual lecture format (TEAMS), residents have the opportunity to both receive and deliver presentations depending on level-of-training, with senior residents delivering more lectures than junior residents. One advantage of virtual lectures is that we have seen an increase in the number of medical students, non-physician providers, and other attending physicians in the department who are able to participate in these lectures since hosting lectures virtually.

While we recognize that there are certain workshops and learning opportunities that are better offered as in-person activities, making lectures available virtually has had an overall positive impact on our department. Our institution has a wide variety of clinical sites throughout the city, so it is helpful for residents and attending physicians lecturing not to have to travel to two disparate sites for the morning didactic lectures and afternoon clinical rotations. Dermatopathology has been one area of our residency training program that has transitioned to virtual format. Residents participate in weekly dermatopathology conferences where they have been able to learn and study from virtual slides through live-interactive sessions with dermatopathologists and dermatopathology fellows. Throughout the COVID-19 pandemic, a number of slides were saved onto the KiKoXP platform (created by Dr. Jon Ho—Dermatopathology at the University of Pittsburgh, so that residents can continue to learn from and review these slides in preparation for their board examinations. As the dermatology board examinations for residents have transitioned to a fully virtual platform, it is crucial for residents to gain familiarity and comfort with viewing dermatopathology slides not only through a traditional microscope but also through a digital slide viewer.

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In the area of medical dermatology, our institution has also created a virtual transplant dermatology curriculum geared towards educating residents about the specific dermatologic needs of solid organ transplant recipients. Because solid organ transplant recipients are at a significantly increased risk of developing skin cancer and opportunistic infections, we felt that specific education targeting the lifelong management of this population was necessary. Our curriculum included synchronous virtual case-based interactive discussions and a reading curriculum that included pertinent primary literature covering transplant dermatology topics. We conducted a study to assess the effectiveness of our curriculum using pretest and posttest assessments to survey knowledge of topics and resident self-rated confidence with the material. In sum, we found that after our curriculum, residents not only achieved significantly higher scores on the assessment but also felt more confident about managing transplant patients in the future *(unpublished)*.

In addition, dermatology residents rotate monthly on the UPMC Teledermatology inpatient and outpatient EPIC eConsults (asynchronous, physician-to-physician) and eDermatology (asynchronous, consumer to physician) platforms the same as any in-person clinic with attending preceptor. Residents also participate in synchronous, or virtual video visits with attendings using Vidyo. Residents are exposed to general and complex medical dermatologic conditions. Residents are encouraged to perform research on teledermatology outcomes.

Discussion

In the introduction above, we present our single-institution experience with teledermatology and virtual learning integration in resident education. Institutions from around the world have also integrated teledermatology into resident education curriculum and have found a variety of uses for it. For instance, virtual, case-based resident education programs have facilitated resident exposure to uncommon pathologies. An online curriculum focusing on cutaneous manifestations of vasculitis and autoimmune connective tissue diseases was created and offered to dermatology residents at varying levels of training and at unique training programs [1]. The study showed that the completion of the online modules significantly improved knowledge of diagnosis, evaluation, and management of vasculitides and connective tissue diseases, which provides further support for the utility of supplemental virtual didactics for residents, especially in the setting of rarer pathologies [1].

In addition to virtual didactics focused on specific patient populations and cutaneous disease, virtual dermoscopy education has also been demonstrated to be efficacious. One study assessed physician improvement in identifying malignant skin lesions on dermoscopy before and after either a live lecture or an asynchronous, online lecture. The study showed that both live lecture and asynchronous lecture groups significantly improved physician ability to identify malignant lesions, with no difference in the improvement of pretest and posttest scores between physicians who attended live and those who watched the virtual lecture [2]. An additional study showed new dermatology residents desired more formal dermoscopy training, given that 38% of residents reported lacking structured dermoscopy education. In response, an online dermoscopy curriculum aimed at incoming residents was developed and shown to significantly improve the identification of malignant lesions [3]. Open-access online dermoscopy courses are also available through DermNet NZ, and free video lectures created by the International Dermoscopy Society are available through YouTube. In sum, virtual dermatology resident education represents a novel and powerful method of increasing access to other teaching opportunities that can further enhance and personalize the trainee's residency experience.

Virtual Learning in Dermatologic Surgery and Cosmetic Dermatology

Virtual teaching experiences geared towards dermatologic surgery have also been implemented.

Two studies have shown the effectiveness of a flipped classroom approach in teaching dermatology residents procedural skills, using asynchronous videos followed by hands-on skills sessions. The studies showed that this approach significantly improved residents' surgical skills, confidence, and training satisfaction [4, 5]. At our institution, we have extended this flipped classroom approach to preclinical medical students [6]. Students were responsible for watching prerecorded lectures that introduced basic suturing (simple interrupted, subcuticular, instrument ties) and biopsy (shave and punch) techniques before attending a hands-on workshop where they had the opportunity to physically practice surgical skills with faculty and resident guidance. We found that students felt significantly more confident in suturing and biopsy skills after the workshop, demonstrating another way virtual education can enhance the trainee experience at all levels of training.

Virtual training and learning opportunities have extended to cosmetic dermatology as well. The American Society for Dermatologic Surgery has created a variety of remote learning opportunities for resident cosmetic dermatology training. These include online didactic courses, procedural technique videos, cosmetic case series, journal clubs, and live-interactive learning sessions [7]. The American College of Mohs Surgeons also partnered with the University of California Irvine to develop and offer online dermatology courses for cosmetic dermatology and laser use within dermatology [8]. Additionally, individual dermatology resident programs created a virtual faculty exchange program during the COVID-19 pandemic, where sub-specialist dermatologist faculty members from academic institutions throughout the United States delivered lectures on topics ranging from cosmetic dermatology to pediatric dermatology to residents from other institutions. Follow-up surveys revealed that the majority of residents found this program very helpful. Cost analyses demonstrated that this virtual education program eliminated a potential cost of more than $15,000 in travel expenses [9].

Virtual Conferences in the Era of COVID-19

Due to the COVID-19 pandemic, dermatology conferences and meetings transitioned to a virtual format. Prior to the pandemic, conferences and meetings were important means for residents to continue their education and professional development. One study conducted a global cross-sectional survey of dermatologists and showed that an overwhelming majority of dermatologists were willing to attend virtual meetings and webinars, and that attending virtual meetings was significantly associated with current and future planned teledermatology use and willingness to lead webinars and online teaching [10]. Another study implemented a novel virtual faculty exchange program after the cancellation of dermatology meetings in early 2020. In this program, faculty from one program provided videoconference seminars to dermatology residents at another program with topics spanning medical dermatology, pediatric dermatology, surgical dermatology, cosmetics, and dermatopathology. The study found that all participating residents found the faculty exchange useful, educational, and wanted to continue the program throughout the pandemic and its resolution [9]. Although meetings have begun to transition back to in-person experiences, these findings suggest that dermatology residents find virtual learning effective, and that previous experience and familiarity with web-based learning can help encourage teledermatology utilization and virtual learning efforts in the future.

Teledermatology Training

Finally resident training in teledermatology patient care delivery itself has also gained significant traction in response to the COVID-19 pandemic. Teledermatology exposure during residency training existed prior to the COVID-19 pandemic in various forms, including dermatology consultations within the Department of Veterans Affairs for instance, as well as asynchronous store-and-forward teledermatology (both patient-to-physician and physician-to-physician) and synchronous live video visits. Resident satisfaction with teledermatology prior to 2019 has generally been reported as favorable, pertaining to its ability to further training in dermatology core competencies, like patient care, medical knowledge, etc. [11]. Since the onset of the COVID-19 pandemic, more detailed studies have been published analyzing the ability of teledermatology to train residents. A thematic analysis study for instance examined residents' perspectives on teledermatology and included quantitative analyses of the number of cases residents were exposed to. In addition to satisfying core thematic elements of teledermatology training, like providing a supportive educational environment where residents can take the time to read in-depth about diseases without having a patient physically waiting in the room, and high case load exposure, quantitative analysis revealed that teledermatology afforded a higher patient case load per unit time. Authors posit that this feature of teledermatology may accelerate resident's ability to develop visual morphology abilities of various dermatologic pathologies [12].

Drawbacks of Teledermatology in Resident Education

Despite the many advantages of teledermatology integration into resident education, some drawbacks may exist. Within the University of Pittsburgh Medical Center, the initial transition of dermatopathology lectures to a virtual format was met with some challenges. For instance, for newer residents with limited prior exposure to dermatopathology, learning dermatopathology remotely was initially difficult as lecture pace is more challenging to influence remotely. As such virtual live lectures may be more appropriate for residents that have received at least a few months of in-person training. However, this is a single-institution experience and has not been formally studied. Similarly, for asynchronous store-and-forward teledermatology inpatient consults, while the advantage is that residents gain exposure to a larger number of cases in a shorter duration of time as noted above, this may be challenging for more junior residents. To meet these challenges, our institution schedules a 1-month teledermatology rotation after residents have completed several months of in-person clinical training.

Conclusion

Dermatology residens' exposure to and comfort level with using teledermatology and teleconferencing was accelerated by the COVID-19 pandemic. While the University of Pittsburgh Medical Center already had robust methods for incorporating asynchronous store-and-forward teledermatology in both inpatient and outpatient settings, the use of synchronous live video visits has rapidly expanded and remains in place. Teleconferencing and teledermatology training allows resident physicians to develop a breadth of expertise across core dermatology competencies. The development of some of these competencies may even occur at an accelerated rate compared to traditional in-person patient interaction visits alone [12]. As such, it is feasible to suggest that teledermatology will remain a vital part of residency education in the future.

Conflict of Interest The author has no competing financial or intellectual conflict of interest to declare.

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22 Teledermatology: International

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Introduction to International Teledermatology

The Need for Borderless Dermatology

Skin disease is the fourth leading cause of non-fatal disease morbidity worldwide [1, 2]. However, the global burden of skin disease is likely underestimated, as skin involvement is often a secondary manifestation of other systemic processes. Moreover, sparse data exist for geographically isolated regions of the world and areas utilizing non-ICD coding systems [2, 3]. The global need for dermatologic care has contributed to the popularization of alternative healthcare delivery models.

Teledermatology (TD), which is the use of telecommunication technologies to exchange information remotely for disease diagnosis, prevention, or treatment, has enabled the rapid delivery of dermatologic care in multiple countries. According to the 2015 global survey on eHealth by the World Health Organization (WHO), 46% of 125 countries that responded indicated that some type of TD service (from pilot to established models) was being offered to citizens [4]. This is up from 38% out of 114 responding countries from the previous 2009 global eHealth survey [5].

The COVID-19 Pandemic

The WHO declared the novel coronavirus disease (COVID-19) a global pandemic in March 2020 and created guidelines to mitigate viral transmission. Notably, early recommendations were to socially distance, self-quarantine if symptomatic, and limit nonessential medical visits and travel [6]. During this time, TD (and more broadly, telemedicine services) became an attractive platform for maintaining patient continuity and delivering dermatologic care while minimizing in-person contact [7–9]. In a survey of American Academy of Dermatology members, 14.1% (n = 582) of respondent dermatologists had endorsed using TD prior to the COVID-19 pandemic compared to 96.9% that endorsed using TD during the pandemic [10]. Within the US, federal agencies granted payment parity between synchronous telehealth visits and in-person clinical care for Medicare, which helped defray financial barriers

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to TD adoption [11]. Similar trends for TD adoption during the COVID-19 pandemic have been observed internationally. A global web-based survey of dermatologists (n = 733) across Asia, North America, Central/South America, and Europe reported a 64.6% reduction in face-to-face consultations during the pandemic accompanied by a 37.8% increase in TD consultations in all practice settings [12].

Developed Countries and the Human Development Index

TD has undoubtedly allowed for the rapid provisioning of accessible and affordable dermatologic care to rural and underserved populations, helping to minimize healthcare disparities and inequities in developing countries [13, 14]. Such topics will be covered in greater detail in other chapters. In this chapter, we explore the state of TD, including the extent of its utilization and barriers to adoption in the context of non-US developed countries.

While most indices for country development are dominated by unidimensional economic criteria, such as gross domestic product (GDP) per capita, the Human Development Index (HDI) established by the United Nations, is a composite measure of development that considers health, education, and standard of living [15]. Despite its limitations, HDI remains the most widely used indicator of human development; it is generally accepted that countries with an HDI greater than 0.8 display a very high level of human development [15, 16]. Furthermore, bibliometric reports demonstrate that a stronger association exists between the availability of TD research by the number of publications in each country and HDI compared to GDP [17, 18]. Accordingly, the existing literature on TD for all developed countries (excluding the US) on the HDI list has been investigated. China and India have also been included given their rapidly expanding economies trending towards increased human development.

North America

Canada

In 2015, the Canadian Dermatology Association issued a position statement supporting the expansion of TD [19]. Several free to low-cost telehealth resources are available throughout the country [20, 21]. However, key differences exist in the provincial regulatory environment around telemedicine and physician licensing requirements to provide cross-boundary care. In New Brunswick, a physician may deliver occasional or limited telemedicine services without licensure at the discretion of the College of Physicians and Surgeons of New Brunswick on meeting several criteria, including membership with the Canadian Medical Protective Association (CMPA) [22]. In Saskatchewan, physicians are required to meet the same CMPA membership requirements but require a separate telemedicine license to practice telemedicine within the province [23]. British Columbia, Ontario, Nova Scotia, Newfoundland, and Labrador do not specify that a physician must be licensed in their jurisdiction to provide telemedicine. The Ontario eConsult program, which was created with the support of the Ministry of Health offers direct-to-consumer TD using store-and-forward (SAF) services [24].

South America

Chile

There are no regulatory policies surrounding telehealth in Chile; however, the Ministry of Health (MINSAL) has demonstrated support for telemedicine, launching several national initiatives dating back to 2006. National health data from MINSAL corresponding to 2014 through 2016 indicate that 34,493 TD consultations occurred, comprising 26.8% of the overall number of consultations delivered via telemedicine [25].

Argentina

After the onset of the COVID-19 pandemic, the government of Argentina has ratified and made mandatory prior recommendations on telehealth availability that were followed voluntarily [26]. Additionally, a public telemedicine service, Tele-Covid, was launched to deliver specialty services and legislation was enacted to validate electronic prescriptions [27, 28].

Southeast Asia

Singapore

Physicians in Singapore will be required to obtain licensure towards the end of 2023 to deliver telemedicine services under the upcoming Healthcare Services Act [29]. Since the pandemic, Singapore citizens can utilize national subsidies and health savings apportioned from their earned income under the Community Health Assist Scheme (CHAS) and MediSave program to pay for telemedicine consultations for a finite list of medical conditions, including psoriasis [30]. In a small study, web-based TD utilizing SAF technology was employed in a nursing home setting and was received positively by both dermatologists and nurse practitioners [31].

Malaysia

In July 1997, Malaysia launched an initiative called the Telemedicine Blueprint which aspired to strengthen healthcare delivery via telecommunications and multimedia technologies; a telehealth unit was set up under the Ministry of Health in 2000 which oversaw efforts around telehealth facilitation and integration. Teleconsulting, which included TD, saw an increase in the number of hospitals participating from 41 in 2000 to 53 in 2010 [32]. While the rate of teleconsultation has grown, a questionnaire issued to public primary care clinics in 2020 reported that 45.8% of clinics (n = 249) provided teleconsultation, with 60.5% providing only telephone consultation [33].

East Asia

China

The maldistribution of healthcare in China has garnered interest in the application of telemedicine in its impoverished western region. Published studies indicate that telemedicine has been able to deliver primary and specialty care services at a high patient satisfaction rate [34–37]. While telemedicine adoption varies between rural and urban areas, advancements in Internet connectivity, imaging technology, and artificial intelligence (AI) have enabled the expansion of TD [38]. In April 2015, China launched its first hospital-based TD initiative, referred to as the “Cloud Hospital project,” with 750 dermatologists providing synchronous and asynchronous TD consultations to five million patients in Anhui province [38, 39]. In 2017, the Chinese Skin Imaging Database (CSID) was established, which currently has over 4000 hospitals connected to this TD project. CSID has been used to generate disease classification AIs for skin tumors, psoriasis, and vitiligo [38, 40]. With over 900 million Internet users, mobile medicine is a growing trend in China, with applications spanning from AI-assisted remote skin diagnosis to TD services offering both synchronous and asynchronous consultations using SAF technology [38–42].

South Korea

Prior to the COVID-19 pandemic, telemedicine was restricted in South Korea under the Medical Services Act. Moreover, the commercialization of all telemedicine products is prohibited by the Ministry of Health and Welfare (MOHW) and the Korean Medical Association. During the pandemic, the MOHW temporarily lifted telemedicine restrictions, provisionally allowing consultations or prescriptions with physicians over the phone to contain cases [43, 44].

In the past, South Korea has utilized TD for synchronous video consultations in prison settings and in the army, where mobile phones and

SAF technology were used for skin disease diagnosis [45, 46].

Japan

Japan has an informal TD practice [4]. Telemedicine in Japan was technically prohibited under the Medical Practitioners' Act until October 2020, when in response to the COVID-19 pandemic, remote medical consultations were allowed. Lack of technological readiness by an aging population may contribute to Japan's slow adoption of telemedicine [47].

South Asia

India

In March 2020, the Ministry of Health and Family Welfare released Telemedicine Practice Guidelines prepared by the Medical Council of India (MCI) in partnership with the National Institution for Transforming India. Under these guidelines, allopathic registered medical practitioners in India can decide whether teleconsultation is appropriate, allowing them to communicate with patients using all channels of communication (text, audio, video, etc.). However, several implementation challenges have yet to be addressed regarding these guidelines, including ambiguity on insurance coverage for teleconsultations and prescriptions, differences in the country versus local state health regulations, and the technology illiteracy of the masses [48, 49].

Western Asia

Israel

TD has been piloted in the Israel Defense Forces (IDF) Medical Corps between primary care physicians (PCP) and board-certified dermatologists using computerized SAF technology in rural and urban settings. PCPs rated the physician-to-physician TD service favorably with higher satisfaction scores in rural units [50]. A recent survey study on PCPs and other medical specialists working in the IDF Medical Corps indicated that approximately 87% of healthcare professionals use the social media application, WhatsApp™ by Meta Platforms, Inc. (Menlo Park, California), every day in a professional context. Dermatology was the most frequent specialty consulted by PCPs (85.6%) [51].

United Arab Emirates

The Dubai Health Authority (DHA) launched a free telehealth service entitled Dubai for Every Citizen through their DHA mobile application, which supported free voice and video consultation with DHA-certified physicians [52]. Similarly, Abu Dhabi launched a Remote Healthcare Platform which offers AI-assisted diagnoses and remote consultations with physicians via voice, video, or text messages [53]. News reports suggest that a TD pilot of 1000 patients in Abu Dhabi and Dubai utilizing SAF cloud-based dermoscopy technologies to assist with diagnosis has been deployed towards the end of 2021 [54].

Saudi Arabia

Limited TD information is available in Saudi Arabia. However, a recent cross-sectional study of Saudi Arabian dermatologists showed that 57.8% (n = 102) had engaged in at least one instance of telemedicine with a majority expressing satisfaction with patient outcomes [55].

Turkey

A retrospective study in Turkey at a major tertiary hospital found that TD was suitable for 72.8% of the dermatology consultations (n = 147) evaluated during the early stages of the pandemic [56]. An informal web-based survey on TD experiences of Turkish dermatologists during the pandemic found increases in the utilization of video

TD consults and SAF technology. Before the pandemic, 30% and 13% of respondents ($n = 107$) endorsed the use of live video calls using their mobile phones and online platforms, which increased to 42% and 26% during the pandemic respectively. Sixty-two percent of respondents endorsed the use of SAF with their mobile phones before the pandemic, which increased to 51% during the pandemic [57].

Oceania

Australia

In Australia, most telehealth services are funded by the state or federal government [58–60]. Significant emphasis has been placed on TD to supplement access to specialty care in rural Australia. The Princess Alexandra Hospital Skin Emergency Telemedicine Service was launched in 2008 and was responsible for handling external TD referrals for clinics located 600–1200 km away from dermatology services [61]. Similar TD programs have been run at the rural site of Broken Hill, New South Wales highlighting the role of TD in provisioning dermatologic care for remote Australian communities [62].

TD utilization in Australia has increased during the COVID-19 pandemic; multiple inpatient dermatology departments have moved from in-person patient visits to TD [63–65]. Further, the increasing popularity of telemedicine has been accompanied by an interest in direct-to-consumer models of TD, with studies demonstrating consumers favor TD skin assessment services over self-examination [66].

New Zealand

Most published works on TD in New Zealand involve health Waikato, a government Health and Hospital Service serving the Waikato district of New Zealand [67, 68]. Multiple trials have demonstrated that TD is a cost-effective option for patients, reducing both travel and overall appointment times [69, 70]. However, issues with TD image quality, Internet connection, and reimbursement remain present [71, 72]. As such, most patients continue to favor in-person visits over TD [67].

Northern Europe

Norway

The Norwegian Centre for Telemedicine (NST) has been a WHO Collaboration Center for telemedicine since 2002 [73]. TD has been implemented within this program and provides videoconferencing and SAF services. Furthermore, developments in mobile medicine have enhanced the ability of primary care providers to refer patients to TD services [74].

The Norwegian Centre for Maritime Medicine offers telemedical assistance services (TMS) for maritime health concerns [75]. TMS provides free TD services to all ships with an on-call dermatologist capable of providing triage, diagnostic, and treatment recommendations.

Sweden

TD in Sweden focuses primarily on the use of smartphone technology. Mobile applications have been used as teledermoscopy platforms in which patients can submit clinical information to dermatologists for diagnosis [76]. Smartphones and SAF technologies allow general practitioners to consult with inpatient dermatologists at academic hospitals [77]. Dermatologists using mobile applications were able to correctly diagnose patients 78% of the time; however, inter-observer concordance for TD diagnoses was lower than that of face-to-face visits.

Denmark

Denmark has a universal tax-funded healthcare system [77]. Yet, there are still medically underserved areas within the country. The Faroe Islands are described as one such area that has utilized

TD in conjunction with face-to-face consultations since 2003 [78–80]. TD has frequently been used to triage and treat complex dermatological diseases including bullous pemphigoid and hidradenitis suppurativa [78, 79]. Newer studies indicate growing acceptance among general practitioners and dermatologists in using teledermoscopy as a triage tool, although confidence in face-to-face visits still surpasses teledermoscopy-based diagnoses [81, 82].

Finland

In Finland, general practitioners have used TD to consult with dermatologists, lowering patient hospital healthcare expenses and medical travel costs. In a feasibility study at a primary health care center in Ikaalinen, 72% of patients ($n = 25$) spent an average of 15 min on synchronous TD consultations and were spared from travel to a local hospital [83].

The United Kingdom

The United Kingdom (UK) provides free public healthcare through the National Health Service, which has utilized TD for over two decades [84]. Several successful large-scale TD services have been described in the literature, including a 14-year review of services in North and West Kent [85]. The UK has participated in multiple trials assessing TD feasibility, the largest of which being the UK Multicentre TD trial, which demonstrated that TD and conventional face-to-face outpatient dermatology visits were comparable [86, 87]. Additional follow-up studies of the UK Multicentre TD trial found that patients were satisfied with synchronous TD overall [88]. Additionally, SAF-based TD was cheaper than synchronous TD but required additional follow-ups and more patient education [89].

During the COVID-19 pandemic, the British Association of Dermatologists recommended the use of TD as a screening tool for skin cancer referrals [90]. However, multiple studies have shown gaps in confidence for dermatology trainees in utilizing TD in response [91–93].

Southern Europe

Italy

In Italy, mobile applications have allowed patients to send images of suspicious lesions to dermatologists for recommendations [94]. TD has also been used to provide dermatologic care for geriatric patients, as face-to-face visits requiring traveling may present significant barriers to the elderly or chronically infirmed [95].

During the COVID-19 pandemic, Italy experienced significant increases in TD utilization, as people were restricted in their access to hospitals and travel [96–100]. Dermatology consults were performed with more informal forms of telecommunication, including telephone calls and emails, as many dermatologists, and other medical professionals, lacked a centralized telemedicine platform prior to the onset of the pandemic [98, 99]. Notably, while Italy's Ministry of Health has attempted to collect more information on telemedicine options to alleviate the healthcare burden during the height of the COVID-19 pandemic, a central telemedicine option has not yet been implemented [100].

Portugal

Portugal is served by a national health service that has a relative shortage of dermatologists [101]. TD is currently used to explore areas of skin cancer and dermatology surgery triage to make dermatologic care more efficient [102–104]. There has been recent promising work on the use of artificial intelligence in combination with TD to help prioritize dermatology cases, including the DermAI project, which aims to improve inpatient dermatologist referrals using computer vision and machine learning to automate lesion classification [105].

Spain

Spain operates through a national health system that has implemented multiple large TD networks. In 2014, more than 26% of dermatology departments implemented some form of TD. Moreover, 25% of surveyed dermatology programs use TD services exclusively to screen for skin cancer [106]. One TD network based in Seville has been used to effectively provide referrals to the skin cancer and melanoma unit at Hospital Universitario Virgen Macarena for more than 50,000 teleconsultations between 2004 and 2015 [107].

In Barcelona, TD was initially piloted in 2014 to combat increasing specialist wait times and was successful in lowering patient wait times by half [107]. The program subsequently expanded to multiple nearby counties and has been found to be cost-effective [108, 109].

Andalusia is a medically underserved community in Spain with insufficient numbers of dermatologists, leading to dermatology wait times of over 1 year for initial appointments. The Health Administration of Andalusia implemented a SAF-based TD program from 2018 to 2019, which was able to reduce patient wait times and local dermatologist workloads by 77% [110].

Eastern Europe

Hungary

During the COVID-19 pandemic, the Hungarian government passed a temporary set of legal provisions to better regulate and define telehealth services [111]. These provisions were amended in September 2020 into a permanent legal framework for the operation of telemedicine, including minimum infrastructure requirements and regulations for the funding of services. During this time, asynchronous SAF-based TD services were used to reduce the burden of face-to-face visits, showing efficacy as a triage tool for skin cancers [112].

Poland

Poland has implemented several pilot TD programs in response to the COVID-19 pandemic to reduce face-to-face visits. A survey found that less than 10% of patients had used telemedicine prior to the pandemic which increased to 79% during the pandemic [113]. Similarly, 14% of dermatologists had offered TD services prior to the pandemic, which increased to 95% during the pandemic. In 2020, the implementation of a SAF-based skin cancer screening program by the Lower Silesian Oncology Center in Wroclaw helped to triage patients requiring urgent dermatologic surgery during the pandemic [114]. Overall TD programs in Poland are still in their infancy, and most patients and dermatologists express hesitation over replacing traditional face-to-face visits with TD [113].

Western Europe

Switzerland

Dermanet is a teleconferencing system originally developed by a network of dermatologists in collaboration with Roche Pharma AG (Switzerland) currently being used by approximately a quarter of Swiss dermatologists for TD and includes real-time teleconferencing and SAF options [115]. It has been used for complex dermatologic cases and to provide service to rural areas. SAF-based TD has also been employed for skin cancer screening [116, 117].

Austria

A 2018 survey of dermatologists in Austria showed that only 20.4% of respondents offered TD services [118]. The majority preferred to utilize TD for follow-up visits and not initial consultation. Despite this preference, TD has been used in Austria for a range of skin conditions, from the treatment of severe acne to skin cancer screening [119–121]. TD has also been used as a monitoring tool for complex psoriasis patients, including appropriate handling of adverse effects from biologics [122, 123].

Belgium

The use of telemedicine in Belgium is limited to pilot programs [124]. Large-scale telemedicine services have not yet been supported by the public or private health sectors. However, several pilot programs have shown the feasibility of TD and the interest of patients and physicians [124, 125].

Germany

Germany has a universal health care system financed by a mix of public and private funds [126]. Within this, TD remains an emerging practice with few pilot programs [127].

France

TD has been reimbursed as part of the French healthcare system since 2019 [128]. A 2019 survey of dermatologists showed that 19% reported regularly using TD and 13% were planning to start TD [129]. Prior to this, TD has also been used to provide services to the underserved including remote areas of French Guiana [130].

During the COVID-19 pandemic, TD was an attractive alternative to traditional in-person visits. Despite this, dermatologic care was delayed during the pandemic indicating the need for increased TD adoption [131, 132].

The Netherlands

The Netherlands has one of the most robust TD networks in Europe. Following pilot programs in TD, the KSYOS Teledermatology Consultation System was implemented in 2005 [133]. It is supported by the Dutch Ministry of Health and provides a secure platform for general practitioners to conduct TD consults with dermatologists. The KSYOS system is fully integrated within the existing Dutch healthcare infrastructure and 40% of general practitioners actively use TD within the Netherlands. Consultations provided through KSYOS are also fully reimbursed by the Dutch health care system [133–135].

Limitations

Due to the nature of being in a predominantly English-speaking country, evidence for this chapter relies heavily on studies published originally in English and/or translated texts. As a result, the omission of non-English studies should be considered when interpreting the information presented herein. Moreover, countries lacking established nationally funded science programs with few to no published research papers are regrettably overlooked in this chapter. Future attempts to characterize teledermatology practices in less scientifically oriented or remote settings will benefit greatly from consultation with in-country dermatologists (subject matter experts) and/or the usage of web-based survey instruments. Nonetheless, we have taken great care in composing this chapter considering the aforementioned limitations and attest that the information presented is a reliable representation of the available literature on international teledermatology.

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23 Global Teledermatology in Underdeveloped Countries

Jonathan C. Hwang, Joe K. Tung, and Alaina J. James

Introduction

In 2022, the World Population Review identified 78 underdeveloped countries (UDCs), with 44 (56%) countries in Africa and 22 (28%) in Asia (see Fig. 23.1) [1]. Alternative names for UDCs include "low-income countries" used by the World Bank, "developing countries" or "least-developed countries" used by the United Nations, and "emerging markets" used by other international organizations [2, 3]. Although UDC is an unofficial classification, it is based on seven characteristics: (1) low-income per capita; (2) lack of public and private capital for government projects; (3) population explosion defined as birth rate far exceeding death rate; (4) excessive unemployment caused by slow-growing job markets; (5) predominance of agriculture contributing to national income; (6) small and unproductive investments; and (7) diminished productivity with laborers who are malnourished and have limited classroom education. "UDC" refers to the financial, economic, and age-related demographic aspects of a country and does not assess the people and culture of these countries.

In UDCs, dermatologic care is a crucial component of healthcare needs. Approximately 24% of all medical visits in sub-Saharan Africa involve skin-related conditions [4, 5]. Access to dermatologic care is limited, with many patients not receiving the care they need, resulting in poor health outcomes [6, 7]. In comparison to higher resourced countries, a majority of UDCs have a significantly greater number of disability-adjusted life years (DALYs) due to skin conditions, indicating a higher skin disease burden and lower quality of life. For example, the umbrella category "dermatitis" has the highest DALY rate in sub-Saharan Africa, where many UDCs are located [8]. Due to underdiagnosis and suboptimal management, skin infections account for a significant number of morbidities and mortalities (i.e., 23% misdiagnosis rate for Kaposi's sarcoma in Uganda) [9]. Cutaneous tuberculosis, leprosy, leishmaniasis, scabies, cutaneous larva migrans, Buruli ulcer, mycetoma, and lymphatic filariasis are also prevalent in UDCs with humid climates and overcrowded regions. These infections and infestations are curable with prompt diagnosis and treatment, signaling a pivotal role of early access to dermatologic care in improving health outcomes [10].

Despite the significant burden of skin diseases, UDCs have a disproportionate unmet need for dermatologic care due to a lack of dermatolo-

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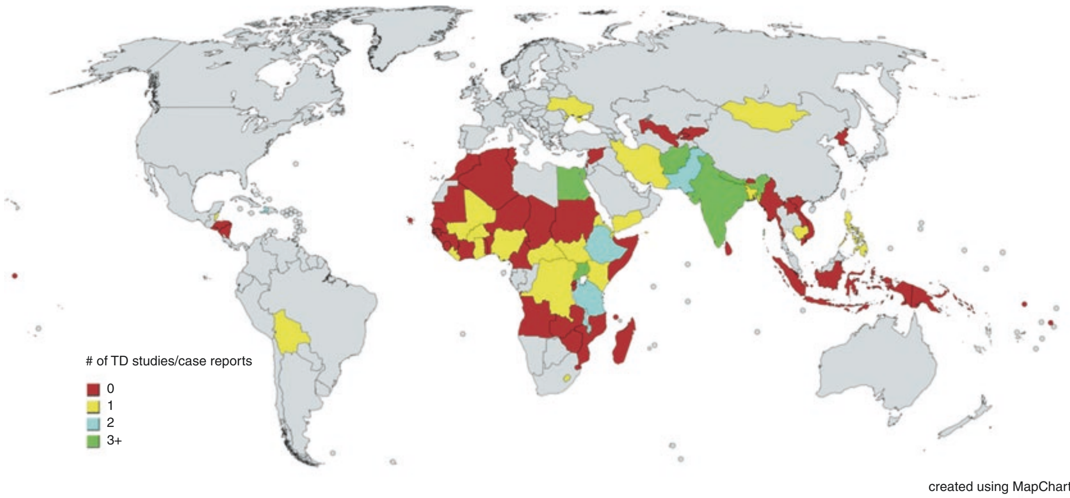

Fig. 23.1 The 78 UDCs color-coded by the number of associated TD studies/case reports identified on PubMed. This map was created using MapChart [69–71]

gists and dermatology training. Of the 55 countries in Africa, there is no opportunity for dermatology specialization in 30 (55%) of the countries [11]. In 2012, the dermatologist-population ratio in Africa was estimated to be 1 dermatologist per 500,000 to 1 million people [12]. In 2021, there were two trained dermatologists in Malawi, a country of almost 20 million people [13]. In stark contrast, the United Kingdom (UK) has 10 dermatologists per million people, the United States of America (USA) has 36 dermatologists per million, and Germany has 65 dermatologists per million (see Fig. 23.2) [14]. Furthermore, similar to those in the USA, many trained dermatologists in UDCs reside in urban areas, leaving suburban and rural populations with limited access to dermatologic care [4, 5, 10]. To address the need for dermatologic care in UDCs, teledermatology has become an expanding, sustainable patient care and dermatology education model.

Historically, challenges to teledermatology (TD) in UDCs have been attributed to lack of Internet accessibility, poor connection quality, and cost of implementation [12, 15]. As a measure of TD utilization, we performed a systematic search of each UDC on PubMed using the keywords "teledermatology" and "[UDC name]." As of May 2022, 47 (60%) of the 78 UDCs have no documented TD study or pilot program on PubMed (see Fig. 23.1).

With increasing globalization and technological advancements, barriers to teledermatology are beginning to be addressed. Higher quality mobile phones have become more affordable and accessible, with 83% of people in UDCs having a mobile phone as of 2018 [16]. Humanitarian efforts have spearheaded new projects to connect resources from developed countries with people living in UDCs. Furthermore, the COVID-19 pandemic has accelerated the adoption of TD globally, with new infrastructure in developed countries benefiting UDCs as well [17].

This chapter reviews the numerous platforms that global UDCs have used to implement teledermatology, along with some of their strengths and limitations. We explore the defining characteristics of successful TD programs and derive lessons on how some programs have built sustainable infrastructure with fewer resources. We conclude with a look toward the future with an emphasis on shared resources and technology to expand effective, accessible, and sustainable TD in UDCs.

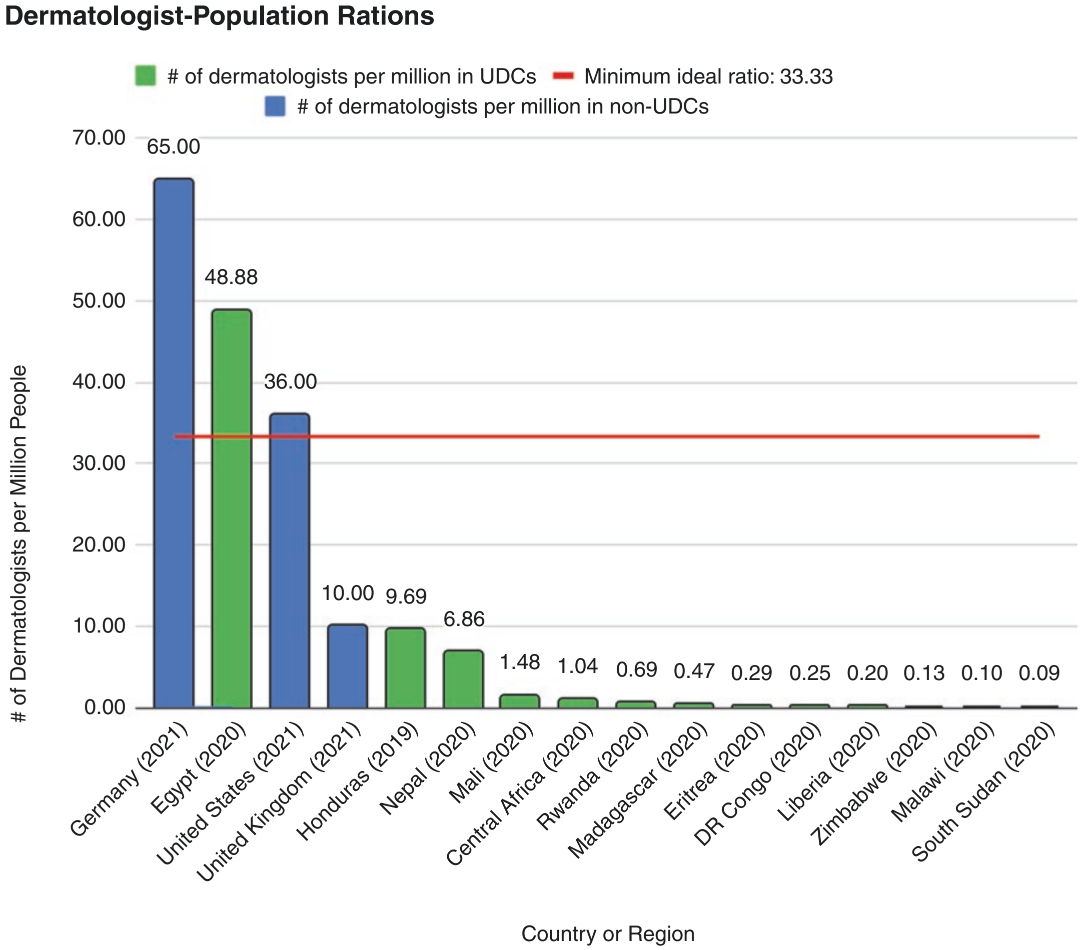

Fig. 23.2 Bar graph showing the number of dermatologists per million people in select countries, illustrating the scarcity of dermatologists in a majority of UDCs (colored in green) compared to non-UDCs (colored in blue). Most UDCs except Egypt fall below the ideal dermatologist-population ratio of 33.33 dermatologists per million people [11, 13, 14, 72–74]

TD Platforms and Methodologies in UDCs

In UDCs, many TD platforms have been used to transmit and store patient history and clinical media. These TD platforms include mobile phone-based social media, cloud-based platforms, and open-source electronic medical record (EMR) systems (see Table 23.1). The healthcare team operating TD programs varies widely, with a mixture of local general practitioners (GPs), nurses, dermatology officers/physician assistants, domestic teledermatologists, international teledermatologists, medical students, and community healthcare workers (HCWs) working together. The members of the TD healthcare team may be within the UDC or include several international countries.

Social Media

As global access to the Internet has improved [18], social media platforms have become a pop-

Table 23.1 Pros and cons of select TD Platforms in UDCs

Type	Platform name	Pros	Cons
Social media	WhatsApp	• Popular worldwide use • End-to-end encryption • Only equipment required is a smartphone • User-friendly in many languages • Can send texts, audio recordings, videos, images	• Decreased ability to store and organize clinical data • Decreased resolution of media • Reports of transmission issues
	Facebook	• Popular worldwide use • Only equipment required is a smartphone • User-friendly in many languages • Discussions via comments on posted photos • Can limit viewer access to certain people	• Decreased ability to store and organize clinical data • Lower image quality • PHI breach risks
	Zoom	• End-to-end encryption • Only equipment required is a smartphone • Optimal for live video instruction and education	• Higher bandwidth for optimal video quality • Only for synchronous TD
Cloud storage	Google apps	• Encrypted platform • HIPAA-compliant • Low monthly cost of $5 USD	• Need to set up HIPAA-compliant platform
	Dropbox	• Encrypted platform [75] • Free licensing for select nonprofits [76] • Greater organization and storage capabilities of each patient's PHI • Device compatibility between windows, mac, iPhone, android, and Linux • Can access from many devices simultaneously • No training or technical setup required	• Free version has limited storage capabilities [77]
EMR	Collegium Telemedicus	• Encrypted platform • Free for all humanitarian efforts • Ready-made telemedicine template software • Backs up information daily • Data archived for a guaranteed 30 years [78]	• 1 case of system messaging error [79]
	Bogou	• Encrypted and password-protected • User-friendly in English, Spanish, French, and Portuguese • Compresses files for reliable transfer of files • Mobile version of Bogou allows portability	• Requires training with specific platform
	ClickMedix	• Encrypted website • HIPAA-compliant • Device compatibility from phone to website • Unlimited images, cases, and site locations	• More costly at $200 USD per month
	iPath	• User-friendly • Free and open-source (customizable) • Uses both email and website functionality • Automatic email notifications	• Requires training with specific platform
	Sana and OpenMRS	• Both applications are free • Device compatibility from phone to website • Sana and OpenMRS work seamlessly together • Designed for low Internet connectivity	• Requires training with specific platforms
Site specific website	Internet-based website	• Can customize to the site's specific needs	• Costly or time-consuming to develop and maintain own website

ular method of daily communication. These platforms have become critical in increasing TD efficiency, usability, and sustainability within UDCs [19]. Many new forms of TD were implemented during the COVID-19 pandemic out of necessity to continue dermatology care in a safer manner compared to face-to-face visits [20].

WhatsApp®, created in the USA, is a free mobile application with many qualities suitable for TD in UDCs. It is used worldwide for everyday communication and has a low barrier to adoption [21]. This platform supports messaging via texts, audio recordings, videos, and images, allowing for synchronous, asynchronous, and hybrid forms of TD. In particular, the ability to send audio recordings in the user's native language has been shown to increase satisfaction and diagnostic accuracy [22]. WhatsApp is outfitted with end-to-end encryption between users, ensuring communication is safe and secure [23]. Some limitations reported with WhatsApp include decreased image resolution of media, and limited storage and transmission issues [24].

The ease of use of WhatsApp has made it the most popular platform for TD within UDCs like Pakistan, Nepal, Djibouti, Egypt, and India [20, 25–27]. Anecdotally, WhatsApp has been successfully used for life-saving TD for a Djiboutian patient with emergent toxic epidermal necrolysis [28] and for a Nepalese patient diagnosed with autosomal recessive congenital ichthyosis [29].

Facebook® is another social media mobile application created in the USA that is now used worldwide. Facebook's user-friendly interface and ability for active discussions in near real-time greatly increase its long-term sustainability in UDCs. The main concerns with Facebook as a TD tool are patient health information (PHI) breach risks and image quality; however, a survey of Nepalese social media users reports that most people would still be comfortable with sending clinical photos of their skin via Facebook. In fact, hybrid TD with mobile phones was preferred over any other methodology in this study [18].

During the COVID-19 pandemic, Nepalese dermatologists reported that Facebook, along with other social media platforms, such as Viber®, created in Israel, and WhatsApp, have been widely used. Such platforms are adequate in supporting the discussion and diagnosis of common skin disorders like fungal infections, alopecia, and eczema [20]. In the Philippines, health care teams used Facebook Messenger as a component of hybrid TD in which teledermatologists receive clinical images via Facebook Messenger® while speaking to patients via phone calls. This combined approach circumvents the often unstable Internet connection in the Philippines while maintaining personal communication with patients [30]. A TD program in Mexico has uniquely implemented an educational discussion platform using the Facebook website. GPs post clinical photos of skin conditions and include pertinent clinical history as a comment associated with those images. Teledermatologists from a local general hospital would then post comments asking follow-up questions, providing diagnoses, and detailing treatment plans. They mitigate PHI risks by limiting which users have access to the images and information [31].

Zoom® is a live video teleconferencing application developed by Zoom Video Communications in the USA equipped with end-to-end encryption; it has been used to provide synchronous TD during the COVID-19 pandemic in UDCs [32]. Zoom has also been a useful tool for building local dermatology capacity through live instruction. Potential limitations of Zoom utilization in UDCs include the need for a stable Internet connection and minimum recommended bandwidth [33]. In an Egyptian TD study, healthcare teams utilized both Zoom and WhatsApp for synchronous and asynchronous forms of TD, respectively harnessing the advantages of each platform to make the TD experience more efficacious. Of the 62 patients that completed a post-TD telehealth usability questionnaire, 57 of them were satisfied with this dual model of teledermatology and valued TD as effective as a face-to-face visit. A majority of the follow-up appointments after the initial TD consults were also carried out using TD, increasing the availability of in-person dermatology appointments for more urgent cases [25]. Another TD program is using Zoom to host live discussions about clinical indications, recommended diagnoses, and suggested care plans with local HCWs [4].

Social media platforms carry many advantages in facilitating sustainable TD systems within UDCs. Most are free to use, familiar to patients and healthcare teams, and can be used with a mobile phone. The main limitations of using social media have been lack of EMR integration, poor continuity of care, PHI concerns, and lower image quality. As EMR compatibility, phone camera quality, and cybersecurity improve over time, these will become less of a hindrance toward developing sustainable TD infrastructure using social media.

Cloud-Based Storage Platforms

Many TD programs in UDCs have also utilized free or low-cost cloud storage platforms for secure and efficient asynchronous TD. Clinical photos taken with either a camera or a smartphone are uploaded directly to a protected cloud storage, where the teledermatologist can review the photos [34]. A TD study in Haiti is using Google Apps™ to create an encrypted HIPAA-compliant platform that only costs $5 USD per month, providing a financially sustainable method to securely transmit sensitive patient information [35]. Another TD program uses Dropbox®, a widely used cloud storage platform created in the USA, for TD care due to its large storage capacity, rapid dissemination capabilities, user-friendliness, and security. It requires no initial training or technical expertise and allows the referring person to send clinical photos and patient history to an entire healthcare team simultaneously [36].

Telemedicine EMR Systems

While social media and cloud storage platforms are more user-friendly, EMR systems built specifically for telemedicine offer higher layers of security and a more organized structure. Many are low-cost or open-source, allowing for UDCs to employ such platforms in providing TD.

Collegium Telemedicus (CT) is a telemedicine system developed in the UK by Collegium Telemedicus Ltd. that is free for all humanitarian efforts in low-resource settings. It offers secure messaging, central storage of patient information, and ready-made templates designed for TD. This platform allows for TD to be trialed and expanded with low financial risk and provides a foundation for UDCs to create an organized system [15, 37]. Médecins Sans Frontières, also known as Doctors Without Borders, has successfully used the CT network to provide sustainable TD to ten UDCs, with most use cases coming from South Sudan, Ethiopia, and the Democratic Republic of Congo. Some dermatology examples of diagnoses made through CT's teledemedicine system include leprosy, a mycobacterial infection, and neurofibromatosis [38].

A TD pilot program in Mali has been using Bogou, an inexpensive encrypted, multilingual tele-expertise platform created in Mali that allows file compression so that clinical information can be sent in areas with poor Internet connection [12]. Bogou is available in many UDCs' official languages, including English, Spanish, French, and Portuguese, streamlining communication for both patients and TD teams. Because of its password protection, encryption, and moderated teams for each patient case, Bogou proves to be a stable and secure method for TD [39].

ClickMedix is a HIPAA-compliant telemedicine platform created by Carnegie Mellon University (Pittsburgh, PA, USA) and the Massachusetts Institute of Technology (MIT, Boston, MA, USA) that offers seamless smartphone-to-website transfer of clinical images, templates for taking patient history and physical exam, and email notifications upon new consults [40]. This platform also allows unlimited images and cases to be uploaded to the encrypted website. While the cost for ClickMedix is more than previous platforms at $200 USD/month, a TD program providing care for patients in Uganda and Guatemala reported that the financial burden decreases as more patients receive appropriate care [41].

iPath is a Switzerland-based telemedicine server that integrates the simplicity of email with the centrality of a website to make an organized, user-friendly EMR system. The referral workflow involves emailing a patient's clinical information to an iPath server. This information is converted into its own page on the server, which is then sent to the teledermatologist with an email notification. Because iPath's code is completely free and open-source, this allows TD programs to create further applications to cater to their specific needs while incurring no additional financial burden. iPath has been employed successfully by two TD projects in Ethiopia and South Africa after they initially encountered problems with more inefficient methods for sending patient information, including basic email, HTML pages, and their own telemedicine software [42, 43].

Sana is a free smartphone-based media and clinical information capture tool developed by MIT that integrates with EMR systems like OpenMRS. This allows HCWs to collect and upload patient information from their phones directly to OpenMRS for teledermatologists to examine. Sana works in areas with poor Internet connection: it can temporarily store files on the phone until the connection is adequate, parse large files into smaller pieces, and has several ways to transfer information [44]. One TD project has used OpenMRS in conjunction with Sana to provide low-cost, effective TD for rural regions of Mongolia [45].

Favorable characteristics making telemedicine-adept EMR systems suitable for TD in UDCs include their low costs, PHI security, and greater layers of organization for each clinical encounter. In addition, the aforementioned EMR systems have a simple design that can adequately function in areas with poor Internet infrastructure.

TD-Site-Specific Websites

TD programs in UDCs can also create their own websites to customize the layout and functionality to suit specific needs. One example is the African Teledermatology Project (ATP), created and funded as a joint effort by three dermatology departments in Austria, Philadelphia, and Australia. This program has provided TD to at least 13 countries (11 of them UDCs) since its inception in 2007. ATP incorporates into its website (africa.telederm.org) educational opportunities for referring HCWs and teledermatologists: monthly clinical case conferences, discussion forums, and a formal dermatology curriculum [40, 46]. ATP also creates more targeted educational programs regarding each of its locations' most prevalent skin conditions. The website's simplicity helps ensure lower latency in areas with poor connectivity [47]. Other UDCs such as Tanzania, Malawi, and Iran have also used their own websites for TD. However, it has proven difficult for some UDCs to develop their own websites, as it requires initial and recurring financial costs to build and maintain a website [13, 48, 49].

Characteristics for Sustainable TD in UDCs

Many TD programs in UDCs have attributed their success and long-term sustainability to the following: creating long-lasting educational impact, standardizing the patient history and physical examination (H&P), and improving image quality.

One of global TD's primary goals is to lessen the dependence of UDCs on higher resourced countries for dermatology consults. The educational impact that TD can provide is of great importance for under-resourced areas. Studies have found that diagnostic concordance increases between referring teams and teledermatologists as local HCWs gain more dermatology exposure over time. One study reports an increased diagnostic concordance from 13% to 50% after just nine TD cases [50] while another shows an increase from 44% to 68% after several cases of TD [51]. By expanding upon the reasoning behind a diagnosis and treatment recommendation, teledermatologists can improve local HCWs' long-term ability to manage similar cases in the future. One TD program in Afghanistan sends pertinent supplementary information about skin conditions through email along with a lengthy explanation of the diagnoses to referring

HCWs [52]. Another Afghan TD program incorporates a virtual grand rounds curriculum at Emory University (Atlanta, GA, USA) featuring prior international cases. This gives both US dermatology residents and faculty more international learning opportunities while also improving dermatology care in Afghanistan [53]. Synchronous TD, while usually more time-consuming and costly than asynchronous TD, allows for the teledermatologist to explain to both the referring team and patient the rationale for diagnostic treatment and answer any questions in real-time [54]. Lastly, providing local healthcare teams with point-of-care dermatology tools and information readily accessible on mobile devices is fundamental to increasing long-term educational impact. A Botswana TD program was able to increase self-learning of dermatology, with five out of six residents seeking out supplementary materials even when not in the hospital [55]. Effective dermatology education should be a central component in any TD program seeking to provide sustainable care.

Standardization of patient H&P collection is also critical within TD infrastructure, as insufficient histories can result in an inability to diagnose or adequately treat patients [36, 46, 47, 56]. Multiple TD programs describe a dermatology-specific history form with the acronym SCALDA for the referring HCWs to better understand what information to collect: "Size, shape, surface; Color; Arrangement; Lesion type; Distribution; Always check hair, nail, mucous, intertriginous areas" [35, 38]. While using referral templates can increase the overall time spent per patient, higher quality patient information provided from these templates can improve teledermatologists' ability to provide a diagnostic recommendation [7, 50].

Since TD is highly dependent on images, many TD quality improvement efforts have focused on image resolution optimization. Poor image quality is often the sole reason why some TD cases (3–8%) result in no diagnosis [12, 41, 46, 52]. To enhance overall image quality, recommended image guidelines involve the following: initial training on using the media capture device [45, 57], obtaining proper lighting beforehand [58], using a uniform background [59], taking at least two pictures of the skin lesion from different angles [38] along with taking pictures of other parts of the body that could provide clues [25], and using optimal image formatting [7, 35] and image compression [51, 60]. Adhering to such measures allow teledermatologists to adequately examine the skin condition in the images and provide the best possible diagnosis.

Barriers to Sustainable TD in UDCs

The most significant limitations for building sustainable TD programs in UDCs include lack of technology infrastructure, cost, inadequate local workforce, and resistance to TD adoption [61].

Poor infrastructure in UDCs can hinder the integration of TD care. Power outages without a backup electricity source, bug infestations leading to mangled electrical wiring, and unreliable Wifi speeds can all disrupt TD workflow [12, 35, 48]. Many UDCs also lack established diagnostic capabilities, including dermatopathology testing [62], skin cultures, and immunohistochemical staining [34, 52, 63]. This lack of comprehensive confirmatory testing can lead to uncertain or inaccurate diagnoses. Moving forward, grants such as the International League of Dermatological Societies' DermLink Grant of up to $5000 can help bridge the financial gap in creating the infrastructure necessary for sustainable TD [64].

An insufficient local workforce is also a common hindrance in low-resourced regions. Understaffed clinics may be hesitant to add on a TD service, as it would create extra work for already overworked employees [46, 65]. A way to sustainably alleviate physician workload is to train other HCWs or students to carry out the necessary steps for TD referrals [41, 43]. Another successful but limited avenue is through the American Academy of Dermatology Resident International Grant, which sends a dozen US and Canadian dermatology residents to multiple UDCs each year to help establish a stronger dermatology foundation in the area and learn more about global dermatology [66, 67]. The traveling residents can help launch TD services along with training local HCWs to maintain TD functionality.

Local resistance to TD often stems from cultural or religious beliefs, concerns about TD's patient privacy, or opposition to seeking foreign help [5, 46]. The ATP has also noted that some HCWs do not like asking for help via TD [12]. One program has remedied this by having medical students serve as on-site proxies within clinics in UDCs. The medical students develop longitudinal relationships with local HCWs, gaining their trust and ultimately increasing the utilization of TD [41].

Quantitative Variables to Measure TD Program Success

Certain objective variables can help measure the overall success of TD programs in UDCs: (1) patient case volume [7, 35, 54]; (2) diagnostic concordance between teledermatologists and local health teams or in-person dermatologists [47, 51, 59]; (3) response time [12, 21, 38]; (4) cost of TD per patient [20, 41, 45, 52]; and (5) overall patient/TD team satisfaction [22, 36, 53]. These five variables are measurable and may be tracked over time to guide management of a TD program's effectiveness and sustainability in UDCs.

Future Improvements of TD in UDCs

Many TD programs in UDCs currently operate as isolated, distinct entities with fewer resources compared to programs like the ATP, a collaborative TD network of dozens of countries. Increased partnerships and shared resources among programs can further strengthen TD's long-term sustainability in UDCs. Future technological advancements will also improve TD in UDCs through increased democratization of information, growing access to Internet and mobile phones, improved image quality, and new innovative applications. One such advancement is Starlink, which seeks to provide a reliable Internet connection to any part of the world via thousands of satellites, potentially serving as a dependable foundation of communication for TD in UDCs [68].

Conclusion

This chapter outlines several ways to lower the barriers to starting and maintaining TD services in UDCs. Cost is a significant concern to mitigate when measuring the long-term sustainability of TD in low-resourced settings. Free social media applications as well as open-source telemedicine and EMR systems may help alleviate these financial burdens. Low-cost cloud storage systems have also proven satisfactory in providing a blend of greater organization than social media platforms and greater simplicity than EMR systems or site-specific websites. Beyond choosing the right vehicle for transferring clinical information, programs can also optimize the impact and quality of TD by including educational components, standardizing information given within referrals, ensuring adequate staffing, and gaining the trust of local patients and HCWs. While there are many obstacles to implementing TD, employing the aforementioned strategies can greatly increase the long-term success of dermatology care in UDCs.

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24 Teledermatology: Current Integration in Modern Healthcare

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Abbreviations

AAD	American Academy of Dermatology
AI	Artificial intelligence
DALY	Disability-adjusted life-years
FTF	Face-to-face
GAPP	Greater access for patients partnership
HIPAA	Health Insurance Portability and Accountability Act

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Importance and Utility of Teledermatology

Telemedicine, allowing for the remote diagnosis and treatment of patients, utilizes telecommunication technology to transfer clinical information between patients and providers, either to supplement or in some instances replace conventional in-person medical appointments [1]. Telemedicine is a rapidly expanding field of medicine with vast utility in a multitude of medical specialties. The COVID-19 pandemic resulted in further adoption of telemedicine, as novel strategies were required to provide quality care while minimizing in-person contact [2]. With about 7.26 billion mobile phone users worldwide, comprising about 90.7% of the global population [3], telemedicine is becoming increasingly useful and accessible for the diagnosis and management of disease. Furthermore, as one of the most visually dependent specialties, telemedicine is particularly useful in dermatology, with associated technology collectively referred to as teledermatology.

Despite recent, rapid adoption of teledermatology stemming from the COVID-19 pandemic, teledermatology has been described in medical literature since the early 1990s [1]. In addition to mere convenience, its utility stems from factors including the global burden of skin disease, the resulting ability to increase access to care for underserved populations, and the shortage of medical dermatologists.

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Burden of Skin Disease

The Global Burden of Disease project is the most comprehensive global epidemiological study, reporting information regarding disability and mortality estimates for a variety of diseases, risk factors, and injuries [4]. The Global Burden of Disease project has found skin diseases to collectively comprise the fourth leading cause of global nonfatal disease burden [4]. An analysis using associated data found increasing age-standardized disability-adjusted life-years (DALY) from 1990 to 2017 in all 50 states and the District of Columbia, suggesting increasing burden over time [5]. Overall, the collective prevalence of skin disease exceeds that of common chronic medical conditions including obesity, hypertension, and cancer [6]. In addition, skin disease accounts for approximately 12.4% of United States primary care visits [7].

Furthermore, the financial burden of skin disease aligns with its prevalence; an analysis published in 2006 found skin disease to be of the top 15 groups of medical conditions in which health care spending increased to the greatest extent between 1987 and 2000. In addition, the 2004 estimated economic burden of skin disease to the United States public was approximately 96 billion dollars: 39.3 billion annual cost coupled with an additional 56.2 billion dollars attributed to quality of life [6]. In 2013, however the direct and indirect costs of skin disease in the United States were reported as $75 billion and $11 billion, respectively, suggesting an increasing trend in cost, in addition to the overall prevalence of skin disease [8]. Yet, despite increasing costs in the United States and worldwide, research efforts and funding have consistently fallen short in comparison to the overall disease burden, especially for underserved populations [4].

Underserved Populations

While teledermatology has been described as early as the 1900s, it was first described as a mechanism to provide care for underserved populations in rural areas as early as 1995 [9]. In addition to economically disadvantaged populations, geographically isolated populations can benefit from teledermatology that enables providers to provide consultations and care with reduced travel, ultimately increasing access to care. A 1997 report describes the utility of three independently designed telemedicine programs to support three underserved populations: Pacific Islanders, migrant farmworkers, and prison inmates [10]. Interestingly, dermatology was the specialty most utilized by remote providers, and teledermatology aided in diagnosis and treatment, both for initial evaluations and for follow-up care [10].

A 2019 review of teledermatology in underserved populations describes teledermatology applications for four primary underserved populations: urban populations, rural populations, low- and middle-income country inhabitants, and underserved medicaid patients [11]. Rather than geographical isolation, underserved urban residents may lack access to conventional care due to time, transportation, or mobility barriers. In addition, teledermatology in the urban setting can vastly increase access to care for incarcerated populations, for which transportation can be costly. In addition to use for the diagnosis and treatment of skin disease of incarcerated patients, a retrospective study also found teledermatology to aid in the education of prison doctors [12]. Interestingly, a 2012 Veterans Health Administration report found urban teledermatology encounters to exceed rural teledermatology encounters [11].

In contrast, the utility of teledermatology in rural underserved populations stems from bridging the distance from patient to provider. In addition, rural inhabitants may only have access to primary care providers, despite the observation that dermatologists are significantly more successful than family physicians at diagnosing biopsy-proven skin cancers [13, 14] and managing pigmented lesions [15]. This is an especially relevant concern as medical knowledge and available information are expanding at incredibly rapid rates, potentially outpacing the expertise of primary care physicians. Lastly, even if care is relatively accessible, time and distance may act as dissuading factors, reducing patients' motivation to seek non-emergent care or recommended annual skin screenings. Teledermatology in the rural setting can increase convenient access to quality care, despite geographical separation.

Teledermatology may be especially useful for low- and middle-income countries, where cellular and Internet access has interestingly outpaced healthcare access [11]. For example, although skin complaints comprise up to 24% of doctor visits in sub-Saharan Africa, only about 14% of countries in sub-Saharan Africa have trained dermatologists [1]. Thus, as similarly described with prison inmates, teledermatology for low- and middle-income countries has been explored not only for direct diagnosis and treatment but for the aid of local primary healthcare providers who can benefit from rapid responses to clinical questions [11].

Lastly, Medicaid and uninsured patients are consistently less likely to see a dermatologist than privately insured patients [16]. Yet, a 2016 study found 48.5% of dermatology visits among Medicaid enrollees from 2012 to 2014 to be conducted via teledermatology [17]. In addition, the percentage of teledermatology visits increased to 75.7% among newly enrolled Medicaid patients. As teledermatology has rapidly expanded since the COVID-19 pandemic, teledermatology application among Medicaid enrollees, traditionally less likely to see a dermatologist, has also likely expanded.

Shortage of Medical Dermatologists

Despite a growing number of dermatologists in the United States, there remains a relative shortage of medical dermatologists [1]. The field of dermatology is consistently limited by long appointment wait times, even for urgent conditions such as evolving skin lesions [18]. A 2009 study evaluated the wait times among rural and urban areas in Ohio by contacting 250 dermatologists by telephone [19]. They found similar average wait times in rural and urban settings, with an overall average wait time for new appointments and established patient appointments of 4.5 weeks and 3.1 weeks, respectively.

However, America's dermatology appointment wait time crisis extends beyond Ohio and has worsened since 2009. A report from the Greater Access for Patients Partnership (GAPP) found that dermatology appointment wait times have increased by 46% from 2009 to 2017; the average wait time to receive a dermatology appointment was 32.3 days in 2017 [20]. In addition, a 2021 national study observed significantly longer median wait times for Medicaid insurance holders compared to Blue Cross Blue Shield and Medicare insurance holders ($p = 0.002$) [21]. Yet, evidence suggests that teledermatology decreases both outpatient and inpatient wait times, increasing overall access to care [22]. Specifically, wait times can be reduced via increased avenues for dermatologic care and via the use of tele-triage systems, which ultimately reduce unnecessary in-person visits and decreases the time for necessary in-person appointments [22].

Long wait times may stem from low density of dermatologists, which differs vastly according to geographical areas [1]. A 2016 analysis of geographic distribution of dermatologists found an overall density of 4.14 dermatology providers per 100,000 individuals, including both dermatologists and dermatology physician assistants [23]. However, whereas 35.0% of dermatology providers practiced in the 100 densest section codes, only 1.5% of dermatology providers practiced in the 100 least dense section codes, signifying dermatologist density inequity [23]. Many rural counties lack local dermatologists altogether [1], despite a physician needs assessment that suggests 1 dermatologist is needed per 30,000 people [24]. Teledermatology has therefore emerged as a unique strategy to bridge the gap among different geographical areas characterized by inequitable dermatologist densities.

Overall, teledermatology has emerged as a unique strategy to combat common problems previously limiting the field of dermatology, including access inequalities for underserved populations and long appointment wait times, likely stemming from the relative shortage of dermatologists. Furthermore, the demand for telehealth options was promptly emphasized during the COVID-19 pandemic. Despite the previously described utility of teledermatology, the field is met with many challenges. This chapter seeks to review historical perspectives of teledermatology, including challenges and advances; current models of teledermatology; the status of teledermatology research, including concordance between teledermatology and clinical dermatology; legal and ethical limitations; and future directions.

Current Models

Model Characteristics and Requirements

Three primary models of teledermatology have been accepted and implemented in practice, each with associated benefits and limitations: store-and-forward, live-interaction, also referred to as real-time, and a hybrid model [22]. The store-and-forward model refers to the asynchronous transfer of digital photography and clinical information, which interferes little with daily workflow and provides flexibility for both patients and physicians across time zones [1]. However, as patient and provider communication does not occur in real-time, additional consultation visits may be required to clarify complaints in instances of incomplete medical history documentation. In addition, there is less opportunity for live, direct patient education [1].

The live-interaction model refers to synchronous video visits, allowing for image adjustments and greater clarification of complaints and questions for both patient and provider [22]. However, greater coordination is required on behalf of both patients and providers, and there is less temporal flexibility for both patients and providers [1]. In addition, the store-and-forward model can provide up to eight times the resolution of live-interactive model, which can reduce provider confidence in diagnosis [25]. Table 24.1 summarizes the benefits and limitations of the store-and-forward and the live-interactive model. The hybrid model seeks to capitalize on the benefits of the prior two models, although likely still requires proper coordination and temporal acces-

Table 24.1 Benefits and limitations of two primary teledermatology models

	Store-and-forward	Live-interactive
Definition	Asynchronous transfer of digital photography and clinical information	Synchronous video visits
Benefits	• Temporal flexibility • Utility across time zones • Still images have greater resolution than live video	• Allows live clarification of history components • Allows live patient education • Allow for regular E/M coding and billing
Limitations	• Additional consultation visits may be requirement for clarification • Reduced opportunity for patient education	• Less temporal flexibility • Less utility across time zones • Greater temporal and logistical coordination necessitated
Requirements	• Device to capture and transfer clinical information (continuous access is not necessary)	• Fast, stable Internet connection • Webcam or continued camera access

In addition to differing benefits and limitations, each teledermatology model has associated requirements, which may be more accessible for different populations based on geographic location, socioeconomic status, and familiarity and comfortability with technology. The live-interactive model requires a fast, stable Internet connection for both parties, which may thereby further create accessibility disparities. Internet speed and connection problems may reduce diagnostic accuracy and hinder effective communication. Similarly, webcam or camera access is required for the entirety of the visit, and synchronous visits require appointment scheduling in advance [26]. In contrast, the store-and-forward model does not require a consistent Internet connection, as images and clinical information can be prepared with Internet access to be uploaded at a convenient time. Similarly, Internet speed is not an important factor, which may increase accessibility. Communication can occur asynchronously thereby reducing the requirement of strict scheduling. In general, the store-and-forward model has less requirements on behalf of both patient and provider [26]

E/M evaluation and management

sibility. Still however patient satisfaction may be improved with hybrid models over the asynchronous store-and-forward model [1].

Store-and-Forward Versus Live-Interactive Models

There is overall scarcity of literature directly comparing the effectiveness and diagnostic accuracy of the store-and-forward model versus the live-interactive model of teledermatology [26]. A 2000 study directly compared both primary models based on clinical outcomes and associated costs [27]. Ninety-six patients were seen using both teledermatology models, and there was an agreement of diagnosis between video call and still image in only 51% of cases. Furthermore, a greater proportion of patients assessed with the store-and-forward model were recommended to be seen in-person with a hospital appointment than assessed via live-interaction. The authors thereby concluded that the store-and-forward model, although cheaper, was less clinically efficient compared to real-time consultation. They further suggest the reduced ability of dermatologists to obtain clinically relevant information via the store-and-forward model impacted diagnosis and patient satisfaction [27]. However, this study was conducted in 2000 with novel and relatively under-developed teledermatology techniques, and therefore likely does not fully illustrate the current concordance and diagnostic accuracy of each model.

A 2008 study found a greater proportion of diagnoses were identical between in-person and live-interactive examinations than between in-person and store-and-forward examinations (80% vs. 73%), albeit differences were not statistically significant [28]. Similarly, diagnostic confidence was nonsignificantly greater for live-interactive examinations than store-and-forward examinations, both of which were significantly lower than that of in-person examinations. These results suggest comparable diagnostic accuracy and confidence between each model, as of 2008.

Video and photo resolution capabilities have greatly increased with the development of advanced technology. A more recent teledermatology study (2017) compared the store-and-forward model to two live-interactive methods, uncompressed video and compressed video, and in-person examination [25]. The uncompressed video, 1920 by 1080 pixels, was transmitted at almost 1.5 gigabits per second, in comparison to two megabits per second characteristic of 1280 by 720 pixel compressed video. As such, the uncompressed video provided greater resolution, yet still failed to compare to the resolution of the JPEG 3648 by 2736 pixel images utilized for store-and-forward examination. The authors observed a significantly higher confidence level for store-and-forward and uncompressed video methods. Thus, the authors concluded that uncompressed video may function to close the resolution gap between traditional live-interactive and store-and-forward models, essentially combining the benefit of high resolution with that of live data collection and clarification [25].

Lastly, a study assessed the diagnostic accuracy and patient satisfaction between a store-and-forward teledermatology model and a hybrid model, comprised of both asynchronous data transfer and live-interactive video conference [29]. Two independent teledermatologists examined 228 patients and 242 lesions, first with a store-and-forward model then with a videoconference. The authors observed a significantly greater diagnostic accuracy with the hybrid model than the store-and-forward model alone ($p < 0.001$). In addition, patient satisfaction was greater with the hybrid model [29]. These results suggest that hybrid application may be superior to the store-and-forward model alone both in terms of diagnostic accuracy and patient education. Ultimately, these comparative studies, while perhaps limited by year of analysis, suggest that both models are relatively comparable, although uncompressed video and hybrid models may supplement the traditional store-and-forward model to enhance diagnostic accuracy, confidence, and patient satisfaction.

Model Preferences

A variety of factors dictate the best teledermatology for a particular setting or clinic, including access to Internet service, equipment cost, and convenience on part of both patients and providers [1]. However, the store-and-forward model is the most widely utilized. For example, a survey-based study assessing teledermatology in Spain found that teledermatology was used at 25 centers in 2009 and 70 centers in 2014 [30]. Among teledermatology users in 2014, 83% utilized the store-and-forward model, compared to 12% real-time and 5% hybrid.

As live-interaction requires stable Internet connection, store-and-forward models may be preferred in regions lacking broadband Internet connection, such as Germany and Switzerland [26]. Similarly, cities, with greater broadband Internet connection availability, may be preferred settings for store-and-forward teledermatology applications in comparison to rural areas. Furthermore, lack of access to video conference equipment may bar individuals from adequately utilizing live-interaction teledermatology applications. However, live-interaction or hybrid applications may improve patient satisfaction.

Teledermatology Delivery Methods: Consultative, Triage, and Direct-Care Models

In addition to the conventional store-and-forward, live-interaction, and hybrid models, teledermatology has similarly been categorized based on healthcare delivery models, including the consultative model, triage model, and direct-care model [31]. These healthcare delivery models highlight the utility of teledermatology beyond the direct dermatologist–patient relationship, such as via consultation and triage.

The consultative model is a healthcare delivery model in which dermatologists serve as consultants to referring doctors, with the former referred to as the specialist and the latter the referrer [31]. Patients remain under the direct care of the primary care provider throughout the consultation. The consultative model is the most widely practiced teledermatology delivery model in the United States, and it is performed via both store-and-forward and live-interactive methods.

The triage model refers to the prioritization of patients based on the severity of presenting illness or condition [31]. Dermatologists can incorporate the triage model into their workflow by utilizing teledermatology techniques to preview cases and determine the order in which in-person consultations should be conducted. Store-and-forward methods are typically used for triaging. Lastly, the direct-care model describes the process of directly providing care from specialist to patient via diagnosis, treatment, or follow-up. The direct-care model has traditionally been used for research purposes. However, the COVID-19 pandemic has expanded the use of direct-care delivery of teledermatology [32].

The consultative improves access to specialists among underserved populations, reduces unnecessary clinical visits, and allows schedule flexibility with the use of store-and-forward techniques. However, consultative delivery models are limited in the lack of direct communication between patient and specialist, requiring high-quality initial histories [31]. Triage models may reduce unnecessary referrals and reduce wait lists, especially for individuals presenting with significant disease. Triaging may be particularly useful in settings in which resources are scarce and must be allotted based on the severity of presenting disease [1]. The direct-care model can foster direct communication between patients and treating dermatologists. This model is especially useful for providing flexibility and limiting the necessity of frequent follow-up visits for chronic conditions. However, direct-care delivery is limited by provider diagnostic confidence and the resulting willingness to prescribe medications to patients virtually [1]. Table 24.2 summarizes benefits and limitations associated with each teledermatology delivery model.

Table 24.2 Benefits and limitations of three primary teledermatology delivery models

	Consultative	Triage	Direct care
Definition	Dermatologists serve as consultants to referring physicians	Teledermatology as a means to prioritize patients based on the severity of presenting concern	Direct provision of healthcare services via diagnosis, treatment, and follow-up
Benefits	• Improves access to specialists • Reduces unnecessary clinical visits • Allows schedule flexibility with use of store-and-forward techniques	• Reduces unnecessary referrals • Reduces wait times • Particularly useful with scarce resources	• Direct communication between patients and specialists • Limits the need for frequent follow-up visits for chronic conditions
Limitations	• Lack of direct communication between patient and specialist	• Difficulty assessing how soon patients should be assessed in-person • Variability in depth and quality of assessment for patients evaluated virtually	• Reduced physician willingness to prescribe medications to patients virtually

Teledermatology Technologies

Mobile and Smartphone Devices

Mobile devices have been widely utilized for the delivery of teledermatology, allowing patients to capture images and clinical information from home. Suspicious lesions can be captured for diagnosis, in addition to routine skin or mole images to assess change over time. Mobile device use is a particularly accessible technique for data transfer, as about 90.7% of the global population are mobile phone users [3]. Furthermore, mobile teledermatology is an effective strategy to virtually provide care in both developed and developing nations. Concordance studies have been conducted in both Egypt and Ghana, both of which observed almost 80% diagnostic agreement between in-person visits and teleconsultants [33].

In addition, smartphones, with computer-like capabilities, have been used to evaluate patients. Superior camera resolution characteristic of smartphones fosters their use in teledermatology. Furthermore, there are about 6.64 billion smartphone users in the world today, comprising about 83.07% of the global population. However, there are vast differences between smartphone ownership in developing vs. developed countries; whereas 73.47% of individuals in the top ten developed countries own a smartphone, only 25.39% of individuals in the top ten developing countries own a smartphone [3] thereby suggesting differences in smartphone teledermatology accessibility. As such, relying exclusively on smartphone techniques would depict a great global health disparity.

However, in addition to the transfer of captured images, smartphones foster teledermatology via downloadable applications available on the Google Play Store and the Apple App Store. A 2022 study analyzed available dermatology-related apps on the Google Play Store and Apple App Store and found 632 relevant apps for download [34]. Of these available apps, 62.5% were intended for patient use, 32.1% were intended for provider use, and 5.4% were intended for both. Interestingly, 15.7% of apps reported the use of artificial intelligence (AI), demonstrating the intersection of teledermatology and AI. Yet, the authors describe a lack of app regulation, which may limit their utility [34]. Regardless, this study highlights the influence of teledermatology on app stores today.

A 2017 systematic review of mobile phone-based teledermatology found that eight studies utilized a dedicated teledermatology application to capture images, whereas ten studies utilized default camera applications [35]. A recent pilot study conducted in Gaborone, Botswana similarly found that 96% of healthcare survey respondents were satisfied with WhatsApp as a platform for store-and-forward teledermatology [36]. As mobile-based teledermatology continues to expand, a variety of applications are being utilized for data transfer and capture.

The 2017 systematic review found that most studies assessing mobile-based teledermatology utilized a single phone model to take clinical images [35]. However, one study utilizing three phone models with differing resolutions observed no significant differences in image quality or reported outcome measures [37]. Overall, the mean camera resolution utilized in the included studies was 7.9 MP, with poor resolution characteristic of earlier studies utilizing video graphic array cameras. Although five studies published after 2010 still described poor image quality as a challenge, three studies conducting a format assessment of image quality observed sufficient image quality [35]. However, continued technological advances have led to further improvement in camera resolution over time.

Interestingly, the 2018 survey-based study conducted in Spain, described in section "Model Preferences" found that only 12% of centers used mobile phones for teledermatology [30]. In contrast, 15% of centers utilized teledermoscopy, an available technology described in the following section.

Teledermoscopy

Dermoscopy is a noninvasive, in vivo hand-held visual aid that has been traditionally used for the evaluation of suspicious skin lesions [38]. Although conventionally used for the differentiation of suspicious lesions, its utility has expanded to include the diagnosis of a variety of dermatological disorders, including inflammatory dermatosis, pigmentary dermatosis, infectious dermatosis, and disorders of the hair, scalp, and nails [38]. A meta-analysis comparing dermoscopy with the naked eye found a melanoma diagnostic odds ratio for dermoscopy versus naked eye examination to be 15.6 and 9.0 with the removal of two outlier studies [39]. The authors concluded that dermoscopy is more accurate than naked eye examination for the diagnosis of cutaneous melanoma. However, proper use is necessary for desired results. Inexperienced users achieve less accuracy [33].

Teledermoscopy allows the digital capture of dermoscopic images, such as via a specialized camera. In addition, teledermoscopy mobile phone attachments have been developed to allow direct attachment of a polarized lighted magnifying lens to a mobile phone for dermoscopic image capture from home. A study enrolling 200 patients with 491 lesions observed only 12.3% diagnostic discrepancy of clinical significance between teledermoscopy and in-person diagnosis [40]. Furthermore, teledermoscopy approached 100% sensitivity and 90% specificity for the detection of melanoma and nonmelanoma skin cancers, and only 26% of lesions were deemed unmanageable in the absence of an in-person dermatology appointment [40]. Similarly, a study conducted the following year observed a 100% sensitivity and 97% specificity for malignant melanocytic lesions, in addition to a 97% sensitivity and 94% specificity for nonmalignant melanocytic lesions [41]. However, dermoscopic images were taken by a trained "melanographer" or clinician in these two studies. As such, the prior two studies do not convey the utility of teledermoscopy in which patients themselves capture clinical images.

In addition, expertise of the interpreter can impact diagnosis. A study found that associated clinical histories increased the accuracy of dermatoscopic diagnosis for an inexperienced user, but did not result in diagnostic improvement for an experienced user [42] This suggests that dermatoscopic images may be insufficient for proper diagnosis among inexperienced users. Ultimately, despite the reported success of teledermoscopy, limitations include cost and reliability on user experience.

Teledermatopathology

Dermatopathology refers to the use of microscopy to examine specimen samples and aid in diagnosis of dermatologic conditions. Its integral role in dermatologic diagnosis poses a challenge for teledermatology mechanisms previously described. However, teledermatopathology, a term encompassing telecommunication technology used to interpret digital images of specimens remotely [43], may supplement other teledermatology techniques to provide a clinical *and* histological diagnosis. In addition, teledermatopathology may aid in specimen examination specifically for populations isolated from certified dermatopathologists, for which specimens have been traditionally sent for analysis at distant sites [33].

Teledermatopathology was found to reduce time to diagnosis in comparison to the traditional delivery of class slides [44]. Whereas shipping of slides may require about a week for turnaround, the fastest observed turnaround time via use of virtual slides was only 18 min [44]. However, other studies have found that dermatopathologists spend more time examining virtual slides; as such, whereas the turnaround time may be improved for patients and dermatologists, examination time may increase for dermatopathologists, many of which are already burdened by high case volumes [43].

Teledermatopathology can utilize both live-interactive and store-and-forward techniques [45]. Live-interactive dermatopathology transmission may involve a live consultation in which a consulting pathologist controls a remote robotic microscope. This method allows pathologists to connect with clinicians in real time. However, real-time teledermatopathology may require expensive equipment and logistical planning, especially for specialists practicing across multiple time zones. Furthermore, poorer image resolution is expected in comparison to static images [33].

Store-and-forward techniques include static scanned slide images and virtual slide systems [45]. Static scanned slide images involve the capture of a slide field for transfer. As many microscopes are already equipped with camera technology, this method is less expensive and convenient; however, inaccurate field selection can impact telediagnostic concordance [33]. Virtual slide systems can digitalize entire slides and are therefore less susceptible to field selection errors. Yet, such systems are limited by cost and increased slide preparation time [33].

Teledermatology technology has evolved since its inception. Physicians have a variety of tools at their disposal to integrate teledermatology with in-person clinics. However, further research is necessary to determine the optimal workflow and use of such technology in given situations and for a variety of populations. The subsequent section seeks to illustrate concordance data assessing the consistency of diagnosis and outcomes between teledermatology modalities and traditional in-person clinical visits.

Diagnostic Accuracy/Concordance and Patient Satisfaction

With the recent popularization of teledermatology, a primary apprehension of its use has been whether it is comparable to face-to-face (FTF) in-person encounters in terms of its diagnostic accuracy and concordance. Diagnostic concordance specifically refers to the consistency of the diagnoses made via teledermatology compared to those made during FTF encounters. As a result, many trials have been conducted to explain this relationship and provide support for the continued use of teledermatology.

A systematic review conducted in 2017 aimed to understand the effectiveness of teledermatology in skin cancer diagnosis and management [46]. They reviewed 21 studies and found that overall FTF encounters remained the most diagnostically accurate ($\kappa = 0.90$) when compared to teledermatology ($\kappa = 0.41$–0.63). They also noted however that some studies reported teledermatology to have higher diagnostic accuracy. Diagnostic accuracy was specifically defined as the agreement with histopathology for excised lesions and agreement with the clinical diagnosis for non-excised lesions. Additionally, the diagnostic concordance among the studies without using dermoscopy was 62–94% and those with the use of dermoscopy was 46–90%. Interestingly, the diagnostic concordance was much stronger when the same dermatologist performed the FTF encounter diagnoses and teledermatology diagnoses ($\kappa = 0.95$).

Another systematic review performed in 2018 summarized 12 studies that reported the diagnostic concordance of teledermatology diagnosis to FTF encounters. Among the studies that reported a kappa statistic, the overall concordance indicated moderate to substantial agreement (κ = 0.47–0.91). Two other studies reported aggregated diagnostic concordance of 95% and 80% with these studies having a higher sample size of 166 patients and 263 patients, respectively. Additionally, 12 different studies reported primary concordance rates ranging from 40% to 94%. The large range of varying primary concordance rates can be attributed to the unique methodology of each study and small sample sizes utilized (less than 100 patients).

In general, the diagnostic accuracy and concordance seems to vary among the literature. Nevertheless, teledermatology still proves to be a useful tool that can be used to supplement FTF encounters. Physicians must accurately judge when a FTF encounter is warranted, especially if they are unsure of the diagnosis during a teledermatology visit.

Additionally, since teledermatology is a relatively new modality, it is important to understand if patients and providers are in general satisfied with its use. A cross-sectional study conducted in 2021, assessed patient satisfaction with teledermatology use [47]. One hundred and eighty-four patients completed a survey regarding their teledermatology experience. Overall, 86.4% of participants reported a high satisfaction and experience. Interestingly, there was no significant difference in satisfaction rate based on age, race and ethnicity, and insurance status. Additionally, there was no statistically significant difference between satisfaction and prior experience with using teledermatology. Thus, this study further supports the integration of teledermatology into the general practice of healthcare.

Effect of COVID-19

The COVID-19 pandemic was one of the prime motivators to expand the field of teledermatology. As a result of the sudden need for social distancing, decreasing unnecessary exposures, and quarantining to decrease the spread of the virus, there was a widespread change in healthcare policies and practices [48]. These changes prompted healthcare practitioners to seek a modality which would allow them to continue to communicate with patients regarding non-urgent matters to continue the delivery of healthcare. Telemedicine, in this situation, offered the most practical solution. Due to the many advantages and reliability that telemedicine was able to provide in the face of the new nationwide guidelines and recommendations, many specialties including dermatology rapidly adapted telemedicine to their practices.

Prior to the pandemic, telemedicine was most restricted by its lack of coverage from most insurance companies in many settings [48]. This however was modified as COVID-19 unprecedentedly changed the landscape. One of the most significant changes that allowed for a huge advancement in the utilization of telemedicine was the 2020 policy change released by The Centers for Medicare & Medicaid Services [49]. The new policy exponentially broadened coverage for telehealth services so that patients could continue to receive healthcare remotely. Essentially, standard office or hospital visits would be covered when conducted via telehealth. The policy additionally allows patients to be in any location during their appointment and the physician to work from home or their registered practice location. In addition, the change ensured that live-interactive-based telehealth visits would be reimbursed at the regular rates as with in-person visits. Another vital modification that advanced the face of telemedicine was enacted by Health Insurance Portability and Accountability Act (HIPAA) [50]. The change allowed providers to use non-encrypted platforms for the conductance of telehealth visits. These included platforms such as FaceTime, WhatsApp, Skype, Zoom, and Google Hangouts; this allowed for a large improvement in the ease of telehealth delivery [50].

Individual state laws also dramatically changed to accommodate the use of telemedicine. Most states lifted requirements that forced physicians to have preexisting relationships with their patients in order to prescribe medications via telehealth [48]. Additionally, many states modified their laws to allow physicians to provide telehealth care to those who resided outside of their geographic location thus increasing healthcare access [48].

Overall, teledermatology has created a distinctly unique approach for providing healthcare to patients which was more broadly recognized due to the COVID-19 pandemic. Many providers believe telemedicine will be a modality which will continue to be used moving forward. In 2020, the American Academy of Dermatology (AAD) Teledermatology Task Force subgroup provided members with a survey to assess their perceptions on the use of teledermatology. They found that prior to the pandemic among 582 dermatologists only 14.1% had used teledermatology previously, 96.9% moved to using the modality during the pandemic, and 58% expect to continue to use teledermatology after the pandemic. In conclusion, teledermatology has become an integral part of the modern day healthcare field with most contributions from the COVID-19 pandemic.

Technical, Legal, and Ethical Limitations

As with the use of any technology, there are always limitations that present an opportunity for improvement and change. Interestingly, many studies conducted on the use of teledermatology have also reported on its limitations that have been presented by dermatologists. One of the biggest barriers of utilizing teledermatology is the inability of providers to perform physical exams and inability for palpation that can sometimes support diagnoses [51]. In these cases, teledermatology use is limited and the need for in-person visits will be required. This has especially been noted for full-body skin examinations that are substantially difficult to perform solely over telehealth. Interestingly, a retrospective chart review study found that 60.2% of patients had additional diagnoses when they were seen in-person after follow-up to a teledermatology visit [52].

Another limitation highlighted has been the risk of breach of privacy and its resulting possibility for legal implications [51]. Since HIPAA no longer mandates encrypted platforms to be utilized for telehealth visits, there will always be a chance that private medical information may be breached by hackers. Additionally, since providers and patients can be participating in the telehealth visit remotely, there is always a risk of patient confidentiality being broken if they are not conducting the visit from a private location [51]. Thus, this requires both patient and physician responsibility for ensuring that the visit is conducted in a location that is private.

Furthermore, a substantial barrier to teledermatology is the lack of technology access individuals may have; not everyone has universal access to resources such as wifi, mobile phones, computers, and video cams which teledermatology relies on to function. This is especially significant in individuals residing in nations that lack broad technology infrastructure. As a result, although telehealth has broadened access overall for patients to receive healthcare, it is important to not overlook the population of patients that may lack technological access preventing them from acquiring healthcare.

Ethical implications also arise with the use of teledermatology. Many critics have pointed to the issue that teledermatology can depersonalize medicine [53]. This is because it can lack the emotional connection that is largely developed by the physical presence of a patient and provider [33]. Therefore, it may be beneficial to selectively use telehealth as a supplement to healthcare as some situations may be better suited to be conducted through an in-person encounter. For instance, revealing life-changing news to a patient regarding their health would be most preferentially done in-person so that a physician can adequately comfort and support the patient. Thus, it is essential that physicians recognize the importance of selective use of telehealth and only implement it when appropriate [53].

Conflict of Interest There are no relevant conflicts.

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