



Global Tele dermatology in Underdeveloped Countries

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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 demo-

graphic 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-

J. C. Hwang
University of Pittsburgh School of Medicine,
Pittsburgh, PA, USA
e-mail: joh146@pitt.edu

J. K. Tung · A. J. James (✉)
Department of Dermatology, University of Pittsburgh
Medical Center, Pittsburgh, PA, USA
e-mail: tungjk@upmc.edu; jamesaj@upmc.edu

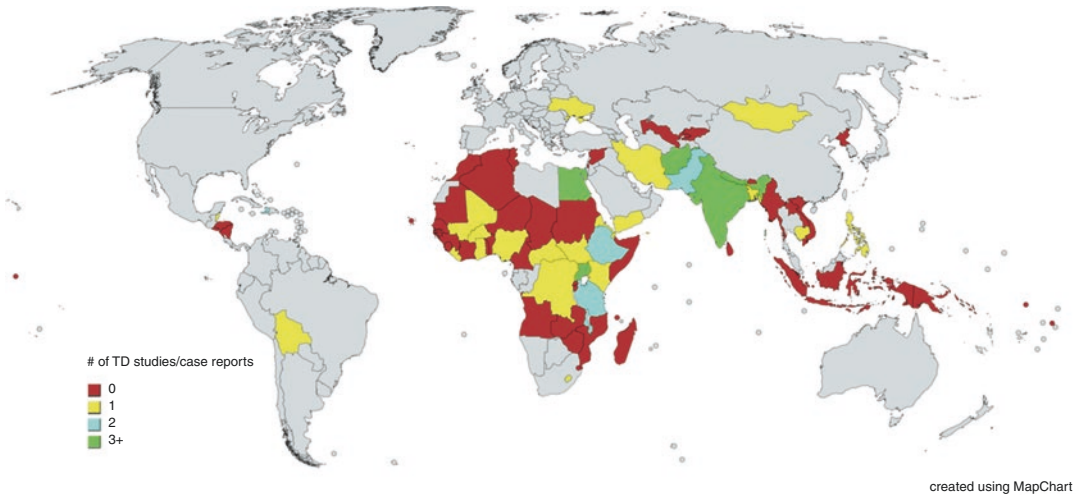


Fig. 23.1 The 78 UDCs color-coded by the number of associated TD studies/case reports identified on PubMed. This map was created using MapChart [69–71]

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, telemedicine has become an expanding, sustainable patient care and dermatology education model.

Historically, challenges to telemedicine (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 key-

words “telemedicine” 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 telemedicine 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 telemedicine, 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.

Dermatologist-Population Ratios

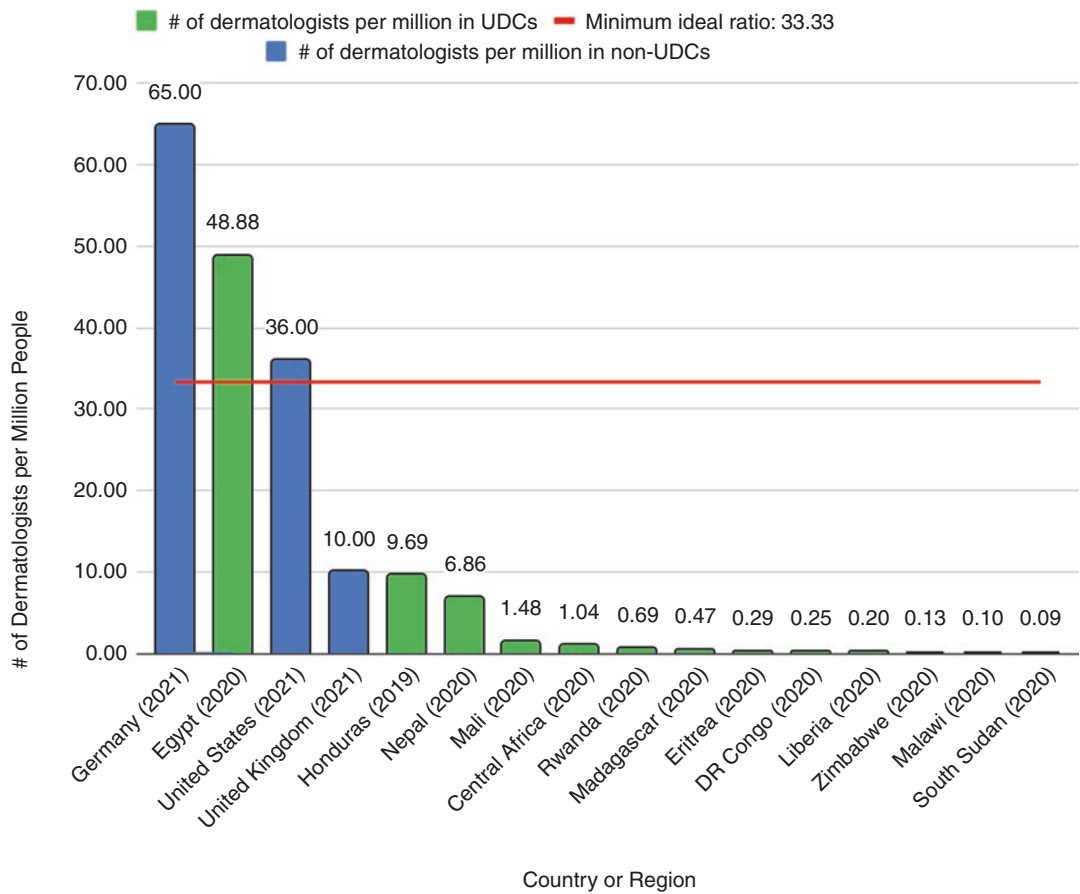


Fig. 23.2 Bar graph showing the number of dermatologists per million people in select countries, illustrating the scarcity of dermatologists in a majority of UDCs (colored in green) compared to non-UDCs (colored in blue). Most

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 assis-

tants, 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	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • Decreased ability to store and organize clinical data • Decreased resolution of media • Reports of transmission issues
	Facebook	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • Decreased ability to store and organize clinical data • Lower image quality • PHI breach risks
	Zoom	<ul style="list-style-type: none"> • End-to-end encryption • Only equipment required is a smartphone • Optimal for live video instruction and education 	<ul style="list-style-type: none"> • Higher bandwidth for optimal video quality • Only for synchronous TD
Cloud storage	Google apps	<ul style="list-style-type: none"> • Encrypted platform • HIPAA-compliant • Low monthly cost of \$5 USD 	<ul style="list-style-type: none"> • Need to set up HIPAA-compliant platform
	Dropbox	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • Free version has limited storage capabilities [77]
EMR	Collegium Telemedicus	<ul style="list-style-type: none"> • Encrypted platform • Free for all humanitarian efforts • Ready-made telemedicine template software • Backs up information daily • Data archived for a guaranteed 30 years [78] 	<ul style="list-style-type: none"> • 1 case of system messaging error [79]
	Bogou	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • Requires training with specific platform
	ClickMedix	<ul style="list-style-type: none"> • Encrypted website • HIPAA-compliant • Device compatibility from phone to website • Unlimited images, cases, and site locations 	<ul style="list-style-type: none"> • More costly at \$200 USD per month
	iPath	<ul style="list-style-type: none"> • User-friendly • Free and open-source (customizable) • Uses both email and website functionality • Automatic email notifications 	<ul style="list-style-type: none"> • Requires training with specific platform
	Sana and OpenMRS	<ul style="list-style-type: none"> • Both applications are free • Device compatibility from phone to website • Sana and OpenMRS work seamlessly together • Designed for low Internet connectivity 	<ul style="list-style-type: none"> • Requires training with specific platforms
Site specific website	Internet-based website	<ul style="list-style-type: none"> • Can customize to the site's specific needs 	<ul style="list-style-type: none"> • 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 telemedicine 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 tele dermatologists 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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