

# Teledermatology: idea, benefits and risks of modern age – a systematic review based on melanoma

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## Abstract

Telemedicine may be described as a modern technology supporting health care at a distance. Dermatology, as a visually-dependent specialty, is particularly suited for this kind of the health care model. This has been proven in a number of recent studies, which emphasized feasibility and reliability of teledermatology. Many patients in the world still do not have access to appropriate dermatological care, while skin cancers morbidity is on an upward trend. Technological development has enabled clinicians to care for diverse patient populations in need of skin expertise without increasing their overhead costs. Teledermatology has been used for various purposes: health care workers can use this technology to provide clinical services to patients, to monitor patient health, to consult with other health care providers and to provide patients with access to educational resources. It seems that teledermatology might be the answer to numerous issues concerning diagnosing, screening and managing cancers as well as pigmented skin lesions.

**Key words:** teledermatology, melanoma, diagnosis.

## Introduction: the origin of telemedicine

Telemedicine might be defined as a new technology which provides medical information and remote health care support. According to the World Health Organization, a broad definition is: “The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities” [1].

Telemedicine dates back to the 19<sup>th</sup> century when ship captains were using radio for getting medical advice and electrocardiograms were transmitted through telephone lines [2, 3]. Teledermatology was reported in medical literature in 1993 when it gained importance in Norway in a variety of medical specialties like radiology and pathology.

## Study design and data collection

The purpose of this study was to document the state of knowledge in teledermatology and summarize its latest

achievements. Firstly, a systematic literature review was made. In order to identify studies relevant to the chosen topic PubMed database was searched for the following terms: “teledermatology”, “melanoma”, and “diagnosis”. Outcomes were restricted to English language papers published between 2000 and 2018. More than 30 articles were found with the online search, but based on their abstracts, further eliminations were made. To expand the review, Science Direct and the JAMA network databases were browsed for compatible studies. Articles identified with the search strategy were read to estimate their suitability for this review and provide as much relevant information as possible. Each reference list of included studies was also hand searched for other applicable references.

## Rapid technological development

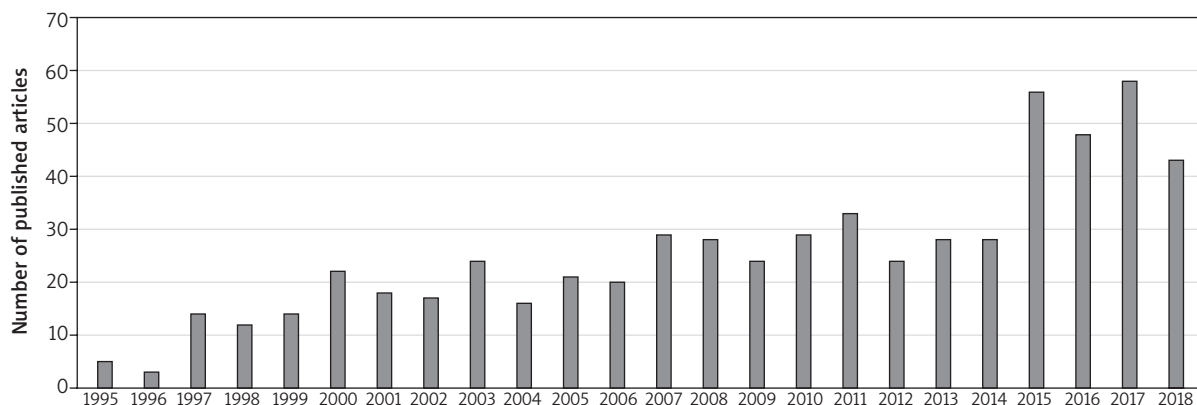
The increasing interests in telemedicine can be explained by a rapid development of new technologies which revolutionized ways of communication and obtaining information (Figure 1). Nowadays smartphones, computers and other Internet connected devices are commonly used. They are cheaper, more portable and efficient, which makes them very suitable for telemedi-

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**Figure 1.** Teledermatology literature since 1995

cine. Access, quality and cost-effectiveness are the basic issues of health care delivery. It seems that telemedicine can meet them all.

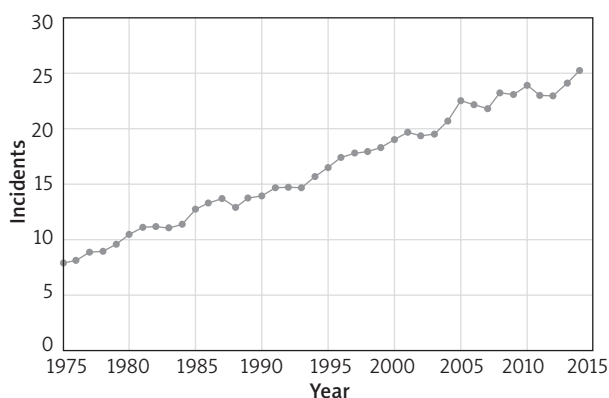
### The burden of dermatological diseases

Dermatology as one of the most visually-dependent specialties is particularly suited for telemedicine. Skin disorders in majority of cases are easily seen by the human eye so they can be accurately captured by imaging technologies [4]. The main goal of teledermatology is to ascertain, store and forward clinical data. The most malignant of skin tumours called melanoma relates to a dysfunction of melanocytes – cells known for producing pigment called melanin. Morbidity of primary cutaneous melanoma has been rising rapidly for over the past 30 years [5]. In the United States, skin cancer it is the most frequently diagnosed one, however only in 1% of cases it turns out to be an invasive melanoma [5] (Figure 2). In 2018, a number of newly diagnosed cases of melanoma in the US was estimated to be 91,270. Due to this disease presumably 9,320 deaths will occur [5]. Melanoma accounts for the majori-

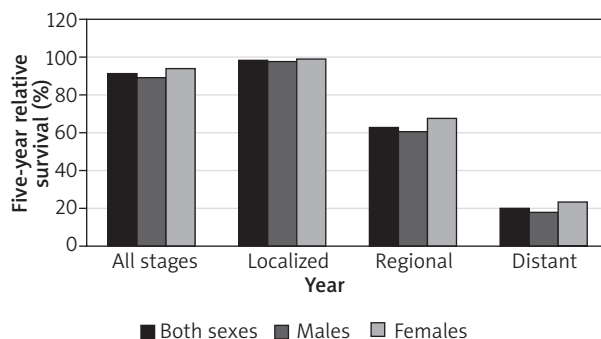
ty of mortality related cancers, but when early detected and properly treated it may be completely cured in most cases. Cancer stage, thickness and level of invasion at the moment of diagnosis account for the treatment strategy. Those characteristics are highly correlated with prognostic factors (Figure 3). The best way to detect skin cancer in its primary stages is to monitor changes of skin lesions, their colour, shape, size etc. It is early detection that determines patients' length of survival.

### Importance of dermatological consultation

Population-based study performed in the Netherlands reported that skin disorders account for 12.4% of diseases seen by the family physician. Most patients notifying about their dermatological ailments are treated only by them without any dermatological consultation [6]. Numerous investigations found dermatologists superior to family physicians when it comes to melanoma diagnostic accuracy and ability of managing pigmented lesions [7]. An Irish study conducted on 493 patients proved dermatologists' precision in 87% of correct biopsy-proven diagnoses in comparison to 22% of correct family physicians' diagnoses [8]. Another study referring



**Figure 2.** Annual incidence rates of invasive skin melanoma. Rates are per 100,000



**Figure 3.** Five-year relative survival (percent) by stage at diagnosis in years 2007–2013

to an Australian dermatology clinic reported dermatologist accuracy at diagnosing histologically confirmed melanomas in 77% of cases over 24% of correct ones performed by general practitioners [9]. Dermatologists play a major role in early detection of melanoma as their attitude is significantly more appropriate. All of aforementioned reasons point out the importance and necessity of dermatological consultation in cases which have even the slightest chance of melanoma diagnosis [10].

### Demand for dermatological care

The average waiting time for a dermatologist appointment was 33.9 days in 2009 but it varies due to geographic area from 19.7 to 73.4 days. Even patients reporting changes of their pigmented melanocytic lesions, which may be a very first sign of malignancy, had to face long queues. Geographic distribution of dermatologists seems to be partly responsible for long wait times. The American Academy of Dermatology carried out a survey among 1,123 dermatologists in which 38% believed that specialists' supply in their community is less than required [11]. Another AAD report, published in 2017, was built on a database containing opinions of 10848 practicing dermatologists. The goal of that report was to measure dermatologists' geographical density according to location. A study came out with a result of 41.8 dermatologists per 100,000 people in Manhattan and 36.6 per 100,000 in Palo Alto (most dense areas) and only 0.27/100,000 in Jamaica and 0.30/100,000 in Kentucky (least dermatologist-dense areas). Results clearly state that some areas are much underserved [12]. Specialization of dermatology is commonly associated with the beneficial aspect of patients' outcomes due visual nature of skin disorders [13]. Many recent studies confirmed that limited access to health care contributes to late-stage melanoma diagnosis, especially without dermatological consultation [14–16]. A recently observed trend among dermatologists – shorter work hours and earlier retirement – are another factors inducing restricted access to this specialty [17, 18]. The demand for physicians is rising due to population ageing and increasing rates of skin cancer [12].

All of the above suggest that geographical distribution and easy access to specialists is crucial in the development of health care policies resulting in patients'

benefits. Teledermatology is expected to be a new tool for monitoring skin lesions, especially in countries with unequal population distribution [19].

### Management of skin lesions

According to the “Guidelines of care for the management of primary cutaneous melanoma”, biopsy is the most accurate method for making a definitive cancer diagnosis. Two different biopsy types can be distinguished: mainly incisional (which removes a part of a lesion) and excisional (which removes the entire lesion). Excisional biopsy is a preferred technique and should encompass the entire width of a lesion. This may be accomplished by using elliptical or punch excision [20]. Shave removal is also in use but rather for cases that are not considered to result in melanoma or if lentigo maligna is suspected, when a broad biopsy specimen is required [21]. Margins should be narrow, usually 1–3 mm clear the subclinical component of melanocytic lesions [22] (Table 1). The cut should be oriented along the longitudinal axis. Incisional biopsy may serve only under certain circumstances such as: low clinical suspicion of malignancy, large lesion and facial or acral location [20]. A repeat biopsy should be performed if a primary specimen is inadequate for diagnosis or for precise microstaging. Each sampled lesion should be successively sent to a pathologist provided with information required for identification purposes (Table 2). There are 3 histologic features particularly important to the procedure's outcome: maximum tumour thickness, presence or absence of ulceration and mitotic rate. These are essential elements of a pathologic report which need to be included [23, 24]. Biopsy is known as a gold standard when it comes to diagnostic accuracy but dermoscopy might be equally useful and precise. Teledermatology, a rapidly growing field of study, requires many pictures to classify and diagnose skin lesions. It seems to be an appropriate approach. Multiple studies had proven high concordance between teledermatology and standard face-to-face clinical diagnosis. What needs to be highlighted is that the credibility of teledermatology tends to improve if additional information is provided. Researchers have found that adding dermoscopy to standard images leads to higher accuracy [25, 26]. Experience of examiners also directly improves efficiency of melanoma detection, especially in comparison to diagnoses based on naked eye visualization alone [27, 28].

**Table 1.** Recommendations for margin thickness for primary cutaneous melanoma

Tumour thickness [mm]	Surgical margin [cm]
<i>In situ</i>	0.5–1
1	1
1.01–2	1–2
> 2	2

**Table 2.** Required clinical information provided with biopsy samples for the pathologist's examination

Essential	Strongly recommended
Age	Biopsy technique
Gender	Size of a lesion
Anatomic location	

## Teledermatology modalities and practice models

Teledermatology can be carried out in three technological modalities: store and forward method, real-time videoconferencing and a hybrid of the above. The store and forward method is the most widely used one. It involves taking pictures and making videos which are then assessed by a dermatologist in a different time and place. No interaction between the patient and the physician is needed, what makes this method relatively inexpensive. It is particularly suited for patients with poor access to health care as there is no need for coordinating scheduled visits. It might be used across different time zones and it interferes less with daily workflow. The method does not depend on Internet connection speed but requires a very high resolution of images. The store and forward method might however require a repeat consultation if clinical data and history are incomplete. Real-time teledermatology is a technology of videoconferencing used for interaction between the patient and the physician. It enables verifying medical history and giving immediate advice. Videoconferencing is also convenient for both the patient and the physician to exchange information and clarify aspects of concern. It may potentially save time due to no need of repeating the same consultation. The method might be expensive because of technical issues and it highly depends on the Internet connection. It requires both the patient and the physician to be available at the same time which is less convenient particularly for practice across time zones and might interfere with physicians' daily schedules. The hybrid method merges advantages of the aforementioned two: time saving aspects of real-time videoconferencing and quality of digital images [25, 29]. Teledermatology examined from the perspective of health care delivery identifies four practice models: consultative (most commonly used), triage, direct care and follow up [30] (Table 3). Development in communications technology creates possibilities for the patients to communicate directly with their dermatologists and means that teledermatology has to be structured in a broader spectrum.

## Practice guidelines for teledermatology

The first guidelines were issued in 2007 by the American Telemedicine Association and then updated in 2016 reflecting new knowledge and new technologies (Figure 4). The guidelines were created to standardize the

practice of telemedicine, to assure quality of service and appropriate care from physicians. Each panel of the guidelines was supervised by experts from the particular field of study. The process of developing was based on professional consensus and rigorous review. The guidelines were created for individual providers, group and specialty practices, hospitals and healthcare systems when providing services via information and communication technology. The guidelines cover: clinical practice, technical requirements and administrative aspects of service delivery. The guidelines refer to three types of consultation typically used in teledermatology: store and forward, real-time videoconferencing and a hybrid of above.

## Emergent technologies and types of mobile applications

Innovations in technology are the driving force behind effective telemedicine care. Rapid development of smartphones and other devices lead to wide availability of mobile applications. There is a considerable number of apps dedicated to dermatology, which might have resulted from a visual nature of skin conditions and arise of medical photography in this specialty. Systems assisting visual diagnostic decisions could be used in telemedicine to support both primary care physicians and specialists. Mobile applications give patients a better access to dermatology consultations. On the other hand, further research is required to determine their quality, safety and efficacy as there are major variabilities among the existing studies. Referring to some researchers, there are several types of smartphone applications, which have been listed and described below [31].

### Educational

The majority of apps designed to assist with melanoma detection primarily served as educational platforms for patients. They were considered to be an inexpensive way to educate about skin cancer diagnosis, risk factors, recommendations for sun protection and instructions for self-examination across wide geographic areas with minimal potential risk for patients.

### Mole mapping

This type is dedicated to patients who would like to take images of a single lesion of concern or create a full

**Table 3.** Teledermatology practice models

Consultative	Triage	Direct-care	Follow-up
Collaboration between a referrer and a specialist. Teledermatologists serving as consultants provide recommendations to a referring doctor. Patients remaining in the care of the primary care provider	A process of prioritizing patients and determining the need for in-person visits	Patients are able to take photos of their skin lesions and send them directly to their physicians	Supports remote medical supervision of chronic skin conditions to assess its activity and optimize therapy

body map of those skin changes. Apps vary in their capabilities allowing to document lesions, follow diagnostic algorithms, track moles in question or record symptoms. It is easy to use at home with no need to travel but the quality and storing security of pictures is still a big concern. For some patients it may be too difficult to take digital images due to lack of technical knowledge. The importance of training a person to take a photograph of good quality is underlined by many researchers.

### Teledermatology

These are apps dedicated specifically for a store and forward model of teleconsultations. They are a good solution for routine follow-up and they can be independent of financial, time and geographical barriers. Patients usually initiate a consultation without any prior referral. Unfortunately, there are some limitations concerning both doctors and patients. Not all specialists are trained in teledermatology or licensed in patients' state of residence. Patients are facing limitations in health insurance coverage, no protection of health information guaranteed and challenges in taking quality photos.

### Diagnostic

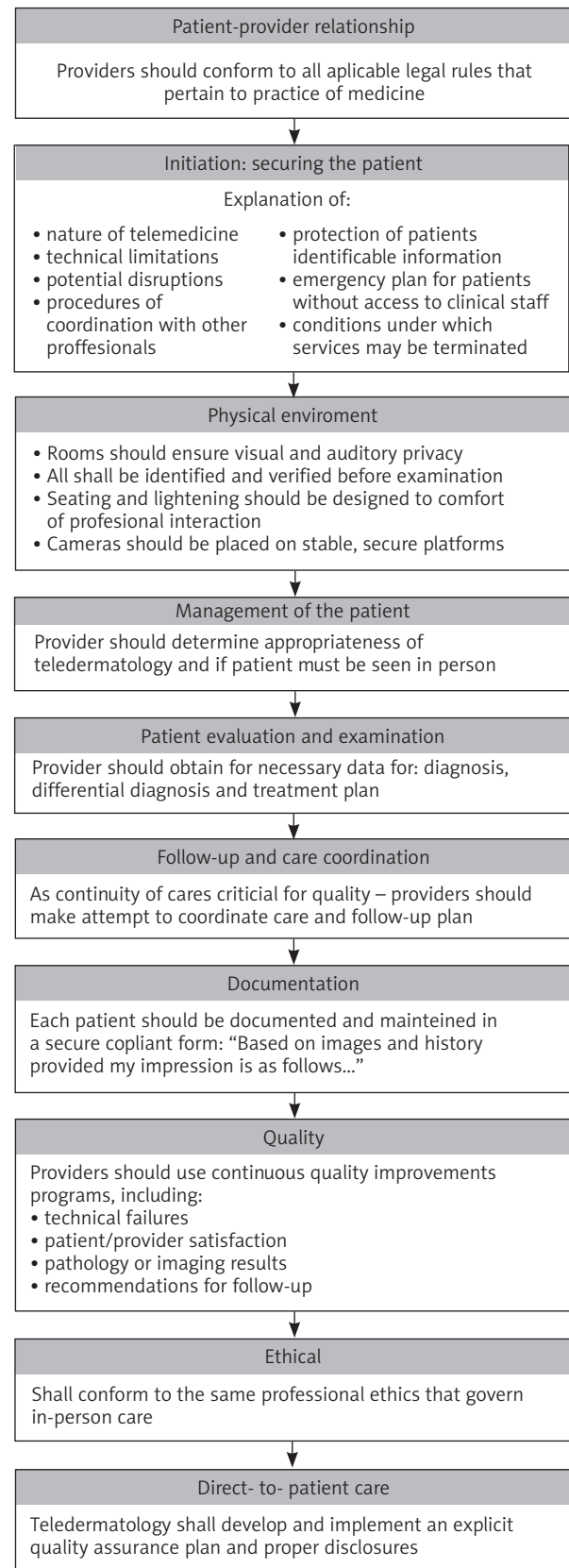
Diagnostic apps allow performing risk assessments of collected lesion photos based on their internal algorithms. They encourage patients to seek medical attention and raise awareness but there are currently no quality standards, regulatory oversights and the risk of false classification is really high. Great future potential has been predicted but some validation or normalization of algorithms is required.

### Research

A research type of apps is for patients willing to participate in studies which can be carried out with the use of a smartphone. It reduces research expenses as clinical information can be entered by smartphones without the need to see a doctor in person. This type of apps allows participants to access research nationwide. The data are anonymized and shared with wider research community but limitations relate to the type of data (no blood, genetic or tissue information can be collected) and validation of patient-reported findings. Ability of intervention, if needed, is also limited.

### Evidence supporting the use of teledermatology

There are multiple studies supporting accuracy and reliability of teledermatology. According to the American Telemedicine Association, it is reported that both store and forward and real-time videoconferencing modalities have diagnostic concordance among teledermatologists. High concordance is also reported for management of decisions made at a distance. Piccolo *et al.* held a study of 66 patients



**Figure 4.** Clinical practice guideline



which resulted in 91% concordance between teledermatology and face-to-face clinical diagnoses [32]. In another study conducted by Arzberger, the research was carried out of patients with a high risk of melanoma. They evaluated 1922 skin lesions and revealed almost a perfect correlation between teledermatology and clinical visits. It was calculated by prevalence and bias-adjusted kappa, based on total body photography, macroscopic and dermoscopic images [33]. Despite telemedicine's big success, the accuracy of in-person visits is still 11% greater than teleconsultations [34]. Moreover, development of teledermatology brought some time-efficient mechanisms and financial benefits. Patients do not need to travel to see a doctor so they spend less time away from usual activities [35]. Dermatologists working remotely can examine and treat patients faster as compared to standard face-to-face visits. All things considered, teledermatology may have a positive impact/influence on duration and effectiveness of today's health care.

### Teledermatology as an educational implementation

Teledermatology might serve as a diagnostic tool as well as an educational platform. Not only patients but also residents or medical students benefit from this health care model. One of teledermatology's concepts is to expand training opportunities and provide physicians living in rural, underserved areas with essential continuing education. A study was carried out among surgeons in 6 European countries for 2 years. Its goal was to assess application of videoconferencing in their daily work routine. Final questionnaires revealed surgeons' excellent satisfaction in 86%, accurate clinical document transmission and improvement of diagnostic potential [36]. Teleconferences have proven their effectiveness in training internal medicine residents, especially in underserved areas [37]. A study carried out in Botswana with the usage of smartphones loaded with point-of-care tools enabled a rapid transfer of information for consultation and education. Utilization of mobile applications increased engagement in self-directed learning at home [38]. Teledermatology may also serve as a tool for connecting dermatologists to one another for continuing specialized education [39, 40]. This cooperation among centres of different sizes and levels enables consulting cases physicians would not have seen otherwise [29]. Tele-education has the potential to alleviate limitations resulting from geographical maldistributions. The uses of telemedicine include education, training, consulting and providing a forum for academic discussion without the need for travel.

### Patients' level of satisfaction

Teledermatology is a rapidly growing field but still innovative and not commonly available. Thus, patients' acceptance of the method needs to be evaluated. A variety of studies concerning teleconsultations and patients' at-

titude have been performed. Since this health care model reduces wait times, need for travel and related costs, patients generally report high satisfaction. A prospective study of 334 patients was carried out in Northern Ireland aiming to recognize benefits of teledermatology and it showed that 85 patients felt comfortable with video consultations and 88 appreciated the time-saving aspect [41]. This suggests general contentment with the real-time teledermatology model. Patients regard the second model of teleconsultations (store and forward) equally as well. Moreover, it has been proven that store and forward consultations do not decrease the quality of life in skin-related diseases comparing to the conventional consultation process [42]. As all of the above studies show, the patients' general approach to teleconsultations is positive in comparison to conventional methods.

### Limitations in teledermatology

In recent years, teledermatology has made it possible to visualize melanomas and other skin lesions in an accessible and immediate way. Despite all the benefits it also has some limitations. In developing countries limitations are particularly connected with an improper technological and physical infrastructure, legal restrictions, lack of demand and limited reimbursements [43]. Authors from the Department of Dermatology in New York distinguished five different categories of limitations: clinical, economic, technological, legal and ethical [4]. Proper understanding of challenges in practicing teledermatology is crucial for purposeful improvements in the system for policy makers, specialists and referring providers.

#### Clinical

Clinical considerations are specifically important and account for proper diagnosis and the following treatment process. The accuracy of teledermatology might be disputed when diagnosing dermatoses such as psoriasis, atopic dermatitis, and actinic keratosis. Teledermatology does not allow palpation while it has been proven that the physical touch is an important asset when examining a patient, equally as crucial as visual diagnosing [44]. Undoubtedly, some conditions are not perfectly suited for the store and forward model. For instance, cases when full body examination is needed, lesions are located in hair-bearing areas, patients with naevus are in the high-risk group of developing melanoma or patients require in-person counselling due to extensive medical records [45]. Asynchronous practice of the store and forward model accounts for efficiency and reduces overhead but this type of communication might be challenging for the referring physicians and dermatologists. Patients seeking clarification, in case they have questions regarding recommendations, might encounter difficulties with getting feedback. Patients have expressed their concerns about improper treatment and insufficient follow-up. The lack of information

exchange can inhibit development and improvement of teledermatology programs [45]. Teledermoscopy presents superiority in diagnostic accuracy in remote-operated cases when compared to clinical photography alone but still remains inferior to in-person encounters [46, 47]. What is more, when it comes to assessing pigmented lesions, general practitioners relying only on teledermatology may risk underdetection of melanomas [48, 49]. In this health care model, in order to take the necessary precautions, both dermatologists and non-dermatologists must be willing to conduct full-body skin examinations [50].

### Economic

Economic arguments such as reduction in the number of referrals, lost employment and travel time are the benefits of teledermatology. The most frequently named challenge is obtaining reimbursements. There is a widespread concern that consultations delivered through teledermatology are reimbursed at a lower rate compared to in-person visits. Most commonly mentioned concerns are delays or even lack of any procedure refunds. Responsibility for aforementioned problems might be attributed to the lower rate of procedures in teledermatology and its relative recentness. In comparison to traditional dermatology, remote procedures are not so well known, documented and organized [45]. Moreover, patients consulted remotely have less frequent follow-up visits and are billed for fewer services which means that corresponding remuneration may not be sufficient to recruit a proper number of clinicians [4].

### Technological

Most frequently mentioned challenges in teledermatology are technological barriers. Evidence suggests that poor image quality, billing systems integration and inefficient, expensive software are areas which require a lot of improvement [4, 51]. Both smartphones and commercially available telemedicine platforms remain expensive, thus there is a need to make them affordable and compatible with the existing medical record systems. Reliance on smartphone-captured images may be misleading, because their cameras are of inferior quality and health care workforce lack formal photography training [52]. All of these issues impair the ability to provide high-quality and timely care.

### Legal

In the consultative practice model of teledermatology, practitioners give recommendations according to histories and images received. Main considerations relate to security of patients' information and medical data transmitted electronically. In the Position Statement on Telemedicine made by the American Academy of Dermatology Association, there is a record that providers should encrypt transmissions to secure health information and

they should include safety understanding in a consent form. Information should be stored on firewall-protected servers [40]. Patients should be properly informed who will have access, how information is stored along with all its benefits and risks [53].

### Ethical

Support to Telemedicine is especially applicable in underserved areas. Providers and systems that utilize telehealth should give notice how it impacts access to healthcare, relationships with patients, capacity for equitable treatment, cost, and quality of life. Physicians express concerns that telemedicine would promote a technology-centric rather than patient-centric model [53]. They also report the fear that variety of technological advances will depersonalize the medical consultations [54]. Teledermatology aims to combat patients' exploitation and training physicians in rural areas, building medical awareness of recipients and their dermatologic acumen, still remembering that education is the core of teledermatology.

### Discussion and future directions

Development of teledermatology gave us a whole new perspective on managing skin disorders with a great range of possibilities and advantages. Teledermatology today is specifically useful for patients with poor access to specialty care. It made immediate screening of skin cancer possible in many places it would not have been seen otherwise. As mobile technologies rapidly continue to improve, many upgrades have been applied to enhance teledermatology. Remaining challenges include creating a number of teledermatology networks, remote diagnostic and therapeutic technologies and improvements in the reimbursement mechanisms. Further development includes assessing the impact of technologies on clinical outcomes. A comprehensive policy should promote further expansion of telemedicine as it seems to have a really promising future.

### Conflict of interest

The authors declare no conflict of interest.

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