

REVIEW ARTICLE

Telemedicine and Teledermatology (I): Concepts and Applications

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Abstract. Telemedicine refers to the use of telecommunications technology to provide health care and medical information. The practice of medicine—and dermatology in particular—is undergoing a great upheaval due to advances in information technology. This article briefly reviews the origin, development, applications, benefits, methodology, and components of telemedicine. Specifically, we will analyze the types and applications of teledermatology, paying particular attention to technical, organizational, and legal aspects.

Key words: telemedicine, remote consultation, teledermatology, store-and-forward systems, real-time systems.

TELEMEDICINE AND TELEDERMATOLOGY (I): CONCEPTS AND APPLICATIONS

Resumen. La telemedicina es el uso de la tecnología de las telecomunicaciones para proveer servicios e información médica. La forma de practicar la Medicina, y específicamente la Dermatología, está sufriendo enormes cambios debido al desarrollo de las tecnologías de la información. Este artículo revisa brevemente el origen, el desarrollo, las aplicaciones, los beneficios, las metodologías y los componentes de la telemedicina. De forma específica se analizan las aplicaciones en la teledermatología y sus tipos, prestando especial atención a los aspectos técnicos, organizativos y legales.

Palabras clave: telemedicina, teleconsulta, teledermatología, sistemas de almacenamiento, sistemas en tiempo real.

Current developments in telecommunications and information technology have revolutionized many aspects of daily life, and this revolution has also had an impact on the practice of medicine, and especially dermatology. The ways dermatologists attend their patients, access medical knowledge, train young doctors, and inform the public have all changed significantly over the past 20 years. The aim of this article is to briefly review the impact of information technology on dermatology as a medical specialty.

Introduction to Telemedicine

The concept of telemedicine is not clearly defined in the literature,¹ but we can consider it broadly as medicine at a distance² implemented by way of healthcare delivery systems that rely on computers, communications technology, and

video and photographic equipment managed by medical personnel trained to deliver healthcare to remote patients. The primary aims of telemedicine are to increase the quality of healthcare and to reduce costs by providing patients remote access to specialized medical resources. Telemedicine facilitates both remote access to medical care and the transmission of healthcare information.³ Recent years have seen steady growth in the practice of telemedicine in parallel with advances in information and communications technologies and a progressive decline in the cost of the equipment and infrastructure required.⁴

Teledermatology involves the clinical evaluation of skin lesions and the review of laboratory findings by dermatologists using telemedicine techniques to diagnose and treat patients at a distance. The primary aim is to provide specialized dermatological care to patients in remote areas. A further aim is to increase diagnostic efficiency and reduce the number of hospital visits.^{3,4}

As in other specialties, the application of telemedicine to the practice of dermatology has encountered resistance among professionals in the field.⁵ However, a still larger group is demanding the active involvement of both patients and doctors in the task of adapting these new technologies to medicine in order to take advantage of the potential but obvious advantages they offer.⁶

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Manuscript accepted, 24 march 2008.

The practical use of telemedicine for delivering healthcare is undeniable when it is used to overcome geographical, social, or political barriers (prisons, wars, etc).⁷ However, the incorporation of teleconsultation into routine practice does not seem justified in countries like Spain that have a good logistic infrastructure,^{8,9} and studies have shown that teledermatology is not cost-effective except from a social standpoint and then only when the patient would have to travel more than a specified number of kilometers.¹⁰ There is, however, some evidence that inexpensive store-and-forward systems could reduce waiting lists¹¹ and facilitate triage, especially in patients with neoplastic diseases.¹² What cannot be ignored is that the number of people using the Internet to obtain medical information is growing steadily,¹³⁻¹⁶ that the technology is increasingly more powerful and generally accessible, and that healthcare is not unaffected by these trends. Moreover, telemedicine is not limited to teleconsultation.⁵ There are already a number of telehealth applications in everyday use that have become standard tools, such as online databases (for example PubMed) and applications for compiling and storing medical records,^{16,17} and these innovations will soon give rise to integrated and interconnected medical information systems. The reality of these developments is unquestionable, but the future of teleconsultation is not because its role is still far from clear.¹⁸⁻²⁰

The body of knowledge concerning telemedicine is currently growing exponentially, and has expanded from a scant 60 articles indexed by Medline in 1990 to almost 9000 articles in the current literature. The aim of this review is to provide an overall, although not exhaustive, overview of what teledermatology is, the current situation, and future perspectives. Given the vast scope of the topic, we have decided to divide the review into 2 parts, the first dealing with the concepts and applications of teledermatology, and the second analyzing advances in research in this innovative field.

Why Teledermatology?

No one would deny—and many authors have written about the subject—that dermatology, because of its significant visual component, is a particularly apt field for the application of telemedicine since the advent of digital photography. The invention of photography in 1839 revolutionized the graphical representation techniques used since the mid-16th century to illustrate medical texts (woodcut engraving and lithography).²¹ Until the end of the 20th century, however, the use of medical photography was limited to training and educational purposes, scientific publications, and case analysis during clinical sessions. Today, almost 2 centuries after the advent of photography, digital imaging technology has set in motion a similar revolution by providing improved graphic quality and greatly simplifying the processing, storage, retrieval, and

visualization of high resolution images. The traditional way of treating patients has changed, and cutting edge dermatology is inconceivable today without the routine use of digital photography.²² We have moved on from using photography only for educational purposes (lectures, books, papers, etc) to using it in routine clinical practice as a complement to physical examination. Just as we should never omit a clinical description of the results of an examination because this constitutes a valuable analysis of what was observed, neither should we omit the inclusion of clinical photographs as another type of finding because such images add a great deal to the clinical examination of the dermatological patient.²³

Current electronic systems for handling medical records include applications that manage the referral of primary care patients to specialists.²⁴ These applications also handle the process of assigning a priority to each case (patient selection) and notify patients about their appointments. The conventional paper referral document includes the basic data set (patient name, birth date, sex, name of referring clinician, institution, and referral date) and the clinical information supporting the referral (personal medical history, reason for consultation, site of lesions, associated symptoms, prior treatment, etc). Electronic referral documents contain the same fields in a digital format. The advantages are undeniable and include legibility, the use of mandatory fields (ensuring minimum quality), and independence from the barriers of time and place (immediacy). Electronic referral also facilitates statistical analysis of data and ensures continuity of care by improving communication between primary care and specialist physicians. In the case of dermatology, it also affords the interesting possibility of attaching digital images of the skin condition that led to the patient visit. These electronic documents are already a tool of undeniable value.

The question is whether the data that can be provided by the primary healthcare clinicians (clinical information and images) will be sufficient to enable the dermatologist to establish a reliable diagnosis and, in certain cases, to extend care to the patient at a distance (teleconsultation) without the need for a face-to-face consultation.^{25,26}

This is not an easy question to answer because a proper evaluation would involve comparing teleconsultation with conventional face-to-face care to clarify a number of factors, including 5 in particular that correspond to the basic areas of research in the field of teledermatology: reliability, validity, outcomes, costs, and patient satisfaction.^{27,28} These topics will be discussed in the second part of this review.

The chief advantage of teleconsultation is accessibility, and there is no question or debate about the use of this technology for patients living in remote areas, or in institutional settings, such as correctional facilities and nursing homes. However, other arguments, in this case related to healthcare policy, have been advanced to justify

the use of teleconsultation in dermatology.^{29,30} The cost of dermatological care in the United States of America in 1997 was 36.7 billion dollars, and this total included the cost of 33 million outpatient visits to dermatologists.³¹ The demand for dermatological care is increased by an aging population and there is a clear upward trend.^{32,33} It is interesting to note that, in the USA, only 40% of skin problems are managed by dermatologists,³¹ and this percentage is even lower in Europe.^{34,35} However, several studies have shown that skin diseases are managed more effectively by dermatologists than by primary care physicians.³⁶⁻³⁸ Various authors hold the view that these findings justify allowing patients direct access to dermatologists without prior referral from a primary care physician³⁹. Telemedicine facilitates patient access to dermatologists from the primary care setting thereby increasing the quality of care.⁴⁰

One of the arguments widely used to justify the practice of telemedicine is that waiting lists for an ordinary dermatological consultation are too long in many hospitals (United Kingdom), making it imperative to identify the patients who urgently need specialist care.⁴¹⁻⁴³

However, before teledermatology is incorporated into routine practice, the reliability, validity, and cost-effectiveness of the technology should be thoroughly evaluated.⁴ Despite the considerable body of research carried out to date, we are still far from obtaining answers to the key questions,¹⁹ especially because much of the published research has had significant methodological defects.^{19,28} These problems will be discussed in detail in the second part of this article.

The Origin and Development of Telemedicine and Teledermatology

Originally, the practice of medicine required doctors and patients or teachers and students to be in the same place at the same time. Gutenberg's invention of the printing press in 1451 provoked the first great scientific revolution making it possible to disseminate medical information on a mass scale. Nevertheless, large hospitals have always been located in the urban agglomerations with the most political weight.⁴⁴ This situation has obviously led to considerable differences in access to medical care and medical training in different areas depending on geographical situation. Later revolutions in transport minimized these differences by overcoming geographical barriers and bringing doctors and patients into closer contact. Inventions such as the steam engine in 1825, the automobile in 1896, and the airplane in 1904 are all examples of this phenomenon. Similarly, improvements in communications systems, such as the telegraph in 1844 and the telephone in 1876, significantly improved communication between doctors and their patients and colleagues. Current advances in these areas are obvious and

have occurred at an ever increasing rate, particularly in data processing capacity, the implementation of fiber optics, and the spread of the Internet (Table 1).⁴⁵

The earliest telemedicine projects date back to 1960, but research in this field was largely abandoned at the end of the 1970s because of the high cost of the technology involved. The end of the 1980s heralded a dramatic improvement in the technology used in computers, communications, and video and photographic equipment, and these advances combined with a steady decline in the cost of these technologies led to a marked increase in the number of telemedicine projects³; since then growth has been exponential. In August 2007, a Medline search turned up 8982 citations relating to telemedicine. The medical specialties currently most active in this research are, in order of number of studies and implementation of the technology, as follows: radiology, anatomic pathology, dermatology, psychiatry, and surgery.⁴⁶

The first teledermatology project took place at the end of the 1960s in the context of a broader telemedicine program linking a medical clinic located in Boston's Logan Airport and the Massachusetts General Hospital, USA.³ Shortly afterwards, in 1970, Murphy et al⁴⁷ published the results of a study in which dermatologists assessed images of skin lesions on either color slides or a black and white television screen. Interobserver agreement among the specialists was 85%, a significantly better result than that obtained when the slides were assessed by general practitioners, who concurred on diagnosis in only 33% of cases. Later studies revealed that dermatologists were more successful in terms of both diagnosis and treatment after evaluating images of skin problems using either real-time video conferencing systems or store-and-forward technology than general practitioners who observed patients in person.⁴² The authors concluded that the use of communications technology was very effective, but too costly to be applied to healthcare. It was not until the technological revolution of the 1980s and the early 1990s that the overhead fell to within an acceptable range for the use of this technology in clinical settings. Telemedicine projects reached a peak in the 1990s, and dermatology was often the leader in the use of teleconsultation.^{4,19}

Norway was the first European country to introduce teledermatology systems. In 1989, a real-time teledermatology service was established linking the University Hospital in Tromsø and a primary care center in Kirkenes situated some 800 km away (a drive of approximately 12 hours).⁴⁸ An initial pilot study published by these 2 participating medical centers reported a 100% diagnostic agreement between face-to-face visits and teledermatology consultations. As a result of these findings, teledermatology was incorporated as a routine service, and the necessary apparatus was acquired locally in 1993 to provide phototherapy to patients in Kirkenes thereby obviating the need for trips to Tromsø for that treatment.

Table 1. The History of Telemedicine

<i>Date</i>	<i>Telemedicine Event or Precursor</i>
1875	First telephone (Bell). Was this the origin of telemedicine? First telephone conversation between health professionals
1900	Delivery of medical services to the Antarctic from Australia using a radio link
1910	First use of an electronic stethoscope using a telephone line
World War II and post-war period	American Department of Defense. Remote support for medical care of deployed troops
1950	Nebraska project. Closed circuit television used for medical monitoring of patients
Early 1950s	First telephone transmission of radiographic images takes place in Pennsylvania
1950s	NASA project for monitoring the vital signs of astronauts in space STARPAHC telemedicine program for space missions. Medical care delivered to patients in remote locations via microwave transmission
1968	The Telediagnosis Program links an airport and a hospital in the USA First use of the term telemedicine Interactive video transmission. Psychiatric consultations
1970s and 1980s	<i>Telemedicine</i> project using the Hermes satellite (USA-Canada) Transmission of video conferences
1980s and 1990s	Decline in interest in telemedicine projects High cost of data transmission
1990	General access to the Internet, a communications network based on the US Department of Defense ARPANET network
1993	Development of protocols (http, ftp) and tools for transmitting images (MOSAIC) over the Internet and the advent of the World-Wide-Web.
End of the 1990s	Resurgence of telemedicine. Concern about access to medical services in rural areas
Today	Revolution in communications technology (Internet, mobile telephony) Advances in digitalization of images Internet access for 195 million people. Sixty million people have access to health information Some 78% of doctors worldwide have Internet access Marked increase in the number of telemedicine projects

Taken from García-Vega FJ.⁴⁵

The rise in interest in teledermatology has occurred at a time when the demand for dermatological services has increased considerably. Finland has also played a leading role in the development of teledermatology.⁴⁹ In the United Kingdom, the number of patients referred to dermatologists increased by approximately 50% between 1981 and 1991, and this increase has given rise to a reconsideration of the general situation of dermatologists in that country.^{4,50} Participation in teledermatology programs has increased worldwide, keeping pace with new developments in communications systems.

Since its first use at the end of the 1960s, teledermatology has proved to be a moderately efficient method for making a diagnosis, achieving reliability rates of between 59% and 80% in subsequent studies,⁵¹ most of which investigated real-

time interactive teleconsultation. However, most of the studies published since 2000 have focused on store-and-forward platforms, because asynchronous systems are less costly, easier to manage, and have a reliability rate on a par with real-time systems.^{19,52} It may be possible to further improve the efficiency of telemedicine by standardizing and maximizing the information included in patient medical histories, using protocols for the acquisition and transmission of images, and storing patient medical records in centralized databases.⁵²

The countries currently leading in the field of telemedicine are rich countries with a low population density (Australia, Canada, the Scandinavian countries, USA) or a marked shortage of specialists (the United Kingdom). Thus, the use of telemedicine can be justified by healthcare policy as well as by geographical factors because it offers obvious

advantages in terms of both greater accessibility and the elimination of geographical barriers.⁸ However, the routine use of telemedicine has not achieved the expected level of popularity even in wealthy countries—such as Norway⁷ and Canada⁵⁴—with a low population density and a tradition of research in this field. Many projects have never gone beyond the pilot stage, and programs often encounter a large number of obstacles.⁵⁵⁻⁵⁷ The use of telemedicine in Norway is limited by problems related to staff remuneration and the time required to carry out teleconsultations,⁷ although it should be noted that the field enjoying the broadest implantation and use of telemedicine is dermatology. The following limitations restricting the routine use of teledermatology have been reported in Australia: lower reliability and accuracy compared to conventional face-to-face consultation; lack of doctor-patient interaction; problems related to remuneration; inadequately trained personnel; and lack of acceptance among potential users.⁵⁸ Recent studies in the United Kingdom have highlighted potential obstacles to the survival of teledermatology programs.^{28,57} If these programs are to succeed, all the parties involved (the health services, medical and paramedical professionals, and the patients) must be flexible and adaptable, especially in view of the emergence of novel organizational patterns and workflows, which should be specifically planned and designed to meet the needs of the new situation.⁵⁹⁻⁶¹ Thus, while the use of teledermatology is developing in a spectacular fashion, many important questions still have to be resolved.

Telemedicine Applications

In general terms, telemedicine can be defined as the use of telecommunications technology to deliver or manage medical information and services.⁶² In the context of care services, telemedicine is the delivery of patient care and the exchange of healthcare and medical information at a distance.

The World Health Organization defines telemedicine as: “The delivery of healthcare services, where distance is a critical factor, by healthcare 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 healthcare providers, all in the interests of advancing the health of individuals and their communities.”^{17,51,63}

Table 2 shows the many different applications of telemedicine including the simple transmission of updated information to distribution lists, bibliographic searches, the use of teleconferencing to discuss cases in clinical sessions and medical conferences, e-training for doctors, patient education, home-based monitoring of selected patients, and all aspects of teleconsultation.^{5,16,64} The communications between the parties can include many types of data, including radiographic or cytological images, images relating to a psychological examination, information sent by e-mail, video or audio recordings of the physician or patient, and tables of physiological findings.⁶⁵

A number of medical specialties have incorporated telemedicine into routine daily practice. These include in particular fields that rely heavily on imaging, such as radiology,

Table 2. The Medical Applications of New Communications Technologies

Telediagnosis	Exchange between physicians of information—text or images—with or without patient participation in order to establish a diagnosis and/or plan a treatment regimen (teledermatology, teleradiology, telecardiology, teleophthamology, telepathology, etc).
Telecare	Remote monitoring of physical and/or biochemical parameters in chronically ill patients (dialysis and cardiorespiratory patients, terminally ill patients, etc) in the patients' homes, elder care facilities, geriatric nursing homes, correctional facilities, etc.
Email cross consultancy	Email contact between physicians to request assessment of a specific disease or condition in particular cases.
Medical emergencies	This novel field within telemedicine deals with the delivery of medical services from urban or rural areas where emergency medical services are available to remote medical facilities located at sea, in isolated areas, in developing countries, or in areas affected by natural disasters, armed conflict, etc.
Teleadministration	The use of communications technology for purely administrative work (for example scheduling and managing appointments)
Teletraining	Participating professionals receive updated information, the results of research, and specifically created multimedia content via the Internet or intranets, obviating the need for physical attendance at conferences or courses.
Virtual consultation	Patients receive medical advice through the Internet. This is probably the area that will grow most in the coming years
Internet healthcare portals	These websites, which are used for both clinical and educational purposes, combine different applications ranging from merely informative (static) pages to completely interactive applications. They may have open access or be restricted to specific users (doctors, authorized members, etc).

Adapted from García Vega FJ.⁴⁵

pathological anatomy, and dermatology, although telemedicine has also been used to deliver medical care in remote locations in response to medical emergencies and disasters, to monitor outpatients at home, and in the practice of ophthalmology, surgery, psychiatry, pediatrics, oncology, and cardiology.^{66,67}

Teleradiology has been largely responsible for the paradigm shift. Although some initial resistance was encountered, almost all hospitals are currently changing over to digital medical imaging systems. This area is being completely revolutionized; physical radiographs are disappearing and simultaneous online access to radiographic images is now available to multiple users. Moreover, digital image data can be manipulated to enhance visualization, and the new technology allows specialists to work remotely.⁶⁸⁻⁷⁰ The use of telepathology has spread rapidly in recent years as the difficulties associated with the large size of the image files generated by the digitalization of histological slides have been overcome, and the use of telepathology systems is now a reality with interesting applications in the field of dermatopathology.⁷¹⁻⁷³ These changes in the way we work have repercussions on both hospital and outpatient care and generate new and promising channels of communication between the different levels of our healthcare system.¹⁶

Telemedicine comprises 4 basic types of services.^{45,74}

Remote Healthcare

Remote healthcare uses telecommunications systems to deliver medical care at a distance. It can be divided into 2 main areas:

1. Consultation and diagnosis: remote consultation involving the participation of one or more medical professionals in order to establish a diagnosis.
2. Monitoring/surveillance: remote monitoring of medical parameters (electrocardiogram in patients with ischemic heart disease, spirometric data in respiratory patients, vital signs in emergency situations, etc), or the course of the disease in patients with chronic disease or those requiring follow-up (for example postsurgical check-ups in skin cancer patients).

Prevention and Screening

Prevention and screening applications facilitate the early detection of diseases with particular impact on public health, such as melanoma⁷⁵ and diabetic retinopathy.⁷⁶

Administration and Patient Management

Administration encompasses the management of the whole healthcare process.

New technology facilitates patient access to the healthcare system (requesting appointments for consultations, laboratory tests, radiographs, etc).

These systems also provide clinicians with more agile systems for accessing and exchanging data by improving response times and generating an electronic patient record (containing the consulting physicians' reports, test results, detailed record of the care process, access to clinical reports, etc).

Finally, as a result of the connection established between the different levels of the healthcare system, a patient record can be compiled that includes both primary and specialized care. This leads to improved information at all levels and eliminates unnecessary duplication.

Healthcare Information

The Internet is an immense repository of information that can be quickly accessed by anyone. The problem is to ensure that the information is correct and supported by good evidence, and to implement systems that will screen out information that fails to meet these requirements. It is therefore essential to use accredited sources, such as the web sites of medical societies and universities.

The Internet provides public access to general healthcare information. This may take the form of recommendations on how to foster good health (nutrition, lifestyle, sun protection, etc), information about a particular disease (melanoma, psoriasis, eczema), or advice designed to prevent disease and to help individuals who want to take care of themselves.^{16,77}

The Internet also facilitates distance learning and remote access to information, providing access to the sources of knowledge and information on levels of evidence that form the basis of the continuing professional development of healthcare professionals in general.

The aim of telemedicine is, therefore, to provide health services that will foster the well-being of society and improve the state of public health in general. As a service, telemedicine not only delivers patient care, but also facilitates administrative processes and the transmission and management of healthcare data. The users of telemedicine systems may be healthcare professionals (medical and nursing personnel, and administrative staff, etc), patients, or members of the general public.

The Primary Aims of Telemedicine

1. To promote equitable access to specialized medical care
2. To improve cooperation between the different levels of the healthcare system (primary and specialized care)
3. To reduce the direct and indirect cost of healthcare
4. To develop the skills of doctors and other medical professionals by way of training based on teleconsultations and video conferences

Table 3. Hypothetical Benefits of Telemedicine in the Delivery of Healthcare. A Report by the Spanish Health Authorities (INSALUD Plan de Telemedicina, Madrid 2000)

<i>Beneficiary</i>	<i>Benefits</i>
Clients	Higher quality healthcare, either because of easy and rapid access to specialist care or because medical professionals have access to more information about the patient.
	Patients are spared the cost, time loss, and inconvenience of travelling, sometimes long distances, for additional visits when a specialist opinion is required.
Healthcare professionals	Availability of abundant information on healthcare subjects
	Access to a second opinion to establish a diagnosis
	Improved clinical and therapeutic coordination
	Support for physicians working in isolated areas. Improved communication between professionals
	Consolidation of the patient's whole medical history into a single unified record accessible to all levels of healthcare
	Availability of computer systems for the management of medical records
	Research and training possibilities
Healthcare administration	Telemedicine favors an equitable and universal healthcare service
	Improved continuity in medical care. Improved communication between professionals
	Delivery of quality healthcare to remote areas of the country Improvements in the quality of care
	Reduced length of stay in hospital, resulting in a more rational use of resources and earlier discharge
	Reduction in the need for travel and transport normally paid for by the healthcare system
	Simplification of procedures

Taken from the Spanish Ministry of Health and Consumer Affairs.⁶³

5. To deliver clinical care at a distance of the same quality as that provided using conventional technology
6. To reduce waiting lists in certain specialist fields by offering teleconsultations from local healthcare facilities
7. To improve and expedite consultation between different specialized care units (superspecialties and centers of technological excellence).
8. To increase the use at home of both primary and secondary healthcare services and the availability of healthcare information to patients at home.

Several countries have led the way in the application of these new technologies and have implemented telemedicine programs some years ago. These countries were early adopters for various reasons, including the following:⁵

1. Difficulty of access to specialist care because of great distances: USA, Scandinavia, Australia, and the South Pacific islands
2. Insufficient availability of specialists: Japan and the United Kingdom
3. The existence of specific programs for planning development strategies: USA, Russia, United Kingdom, Germany, and France

The Benefits of Telemedicine

The many applications of telemedicine can provide a number of benefits to medical institutions, professionals, and patients (Table 3). Certain ethical considerations argue in favor of the use of telemedicine since it promotes universal and more equitable access to healthcare by delivering healthcare to patients in isolated areas.⁷⁸ By integrating the different levels of care, telemedicine also promotes a more comprehensive understanding of the patient, eliminates duplication of work, and favors the development of a new patient-centered healthcare model.⁶⁰

Closer integration leads to increased efficiency because it optimizes the use of healthcare resources, rationalizes the management of demand, minimizes travel and the length of hospital stays, and reduces duplications in clinical work, examinations, and tests.⁷⁹

Since this technology improves access to information at all levels of care, its advantages for training and education are indisputable. In addition to providing professionals with scientific and technological support that facilitates their continued in-service training, telemedicine also raises

awareness about health issues and promotes self-care in the general population.

Moreover, the following advantages of telemedicine are generally accepted as unquestionable: improved access to healthcare services for populations living in remote areas; reductions in the expense associated with patient transfers and travel by patients, doctors, and other professionals; and the dissemination and updating of clinical and administrative knowledge.⁴⁵

How Does Telemedicine Work?

In 1993, the American Telemedicine Association (ATA) (www.atmeda.org) was created in Washington DC, USA as a nonprofit organization with membership open to individuals, medical societies, companies, and other organizations with an interest in promoting the deployment of telemedicine throughout the world.

The elements necessary for interaction in telemedicine are information capture equipment (conventional PC and still or video cameras), data transmission capability (satellite, telephone network, cable, etc), and the means to display information (usually a computer screen).⁸⁰ Two techniques are used: synchronous or real-time communication using a video conferencing system; and asynchronous or store-and-forward systems.^{3,65}

Telemedicine can be practiced by anyone who has the necessary medical knowledge and the appropriate equipment. This equipment is increasingly cheaper and easier to obtain.⁴⁵ The chief advantage of this technology is that it improves accessibility to health care for many populations including patients living in nursing homes,³⁰ bedridden patients living at home, as well as individuals at sea, in airplanes, on battlefields, on mountain peaks, or in the Antarctic. Telemedicine can provide access to specialized medical care wherever it is required.

Satellite communications systems reach the most remote areas of the planet, while asynchronous digital subscriber lines (ADSL) and digital subscriber lines (DSL) enable faster direct transfer of information using the existing telephone network. While most telemedicine systems use the telephone network, other solutions exist.⁸¹ These rely on dedicated local area networks (LANs) or worldwide digital networks, integrated services digital network (ISDN) connections, T1 lines, and global system for mobile communications (GSM) mobile phone networks.⁸² These systems usually employ asynchronous packet switching (ATM [asynchronous transfer mode]) over broadband networks based on coaxial or fiber optic cable, relayed microwave transmission, or other means of data transmission.

With aid of intuitive interfaces and powerful information management systems, it is now possible to provide rapid, sophisticated, and automated telemedicine services.⁵²

However, very simple systems may be sufficient to achieve satisfactory results.¹¹ Such systems are accessible to any user with a minimal knowledge of information technology. Any desktop or portable computer with unsophisticated software and hardware specifications is sufficient for carrying out a teleconsultation with a more than acceptable quality.⁴⁵

The Key Components of Telemedicine Essential for Success

Several components and factors are essential to the success of a telemedicine system,²⁹ all of which must be taken into account (Table 4). The aim of this review is not to offer a detailed analysis of these elements, but it is necessary at least to enumerate them in order to give an idea of the complexity of these systems (a complexity that goes beyond merely technical aspects).⁵⁷

Teledermatology

Teledermatology involves the clinical evaluation of skin lesions and the review of laboratory findings by dermatologists using telemedicine techniques that allow them to diagnose and treat patients at a distance. The primary aim is to give patients in remote areas access to specialized dermatology services. Several authors have identified teledermatology as a subspecialty of telemedicine.^{3,16,25} The term refers to consultations between a patient with a skin disease and a dermatologist (with or without the involvement of a primary healthcare clinician) with the aim of developing a diagnosis and making recommendations for treatment. Telemedicine systems are also used to deliver education in dermatology to healthcare professionals and in some cases even to patients.

Types of Teledermatology

Both research and clinical practice in the field of teledermatology are carried out using either real-time video conferencing systems or store-and-forward systems that capture and store images for later transmission.

Synchronous or Real-Time Teledermatology

In the real-time modality, at least 2 parties communicate synchronously, that is, there is real-time interaction between them. This term can be applied to both video conferencing and an ordinary telephone call. In this encounter, the patient may be alone but is more often accompanied by a primary care physician or an auxiliary technical practitioner specialized in telemedicine.

Table 4. Key Components and Factors Determining the Success of Telemedicine

<i>Area</i>	<i>Factors</i>		
I. Primary care	Acceptance		
	Workflow		
	Acquisition of photographic images		
	Patterns of referral to specialized medicine		
II. Specialized care	Acceptance		
	Quality of images		
	Diagnostic certainty		
III. Patients	Acceptance		
	Suitability of lesions for photography		
	Privacy		
IV. Technology	Feasibility of store-and-forward or real-time systems		
	Acquisition of images	Ease of use	
		Resolution	
	Portability of photographic or video systems		
	Costs		
	Data transmission and security		
	Retrieval and visualization		
	Data storage		
	V. Healthcare systems	Quality of care	
		Access	
Economic justification			
Legal aspects		Malpractice	
		Tendering	

Taken from Romero G.²³

Asynchronous or Store-and-Forward Teledermatology

In store-and-forward systems, information is recorded and stored for later transmission to the dermatologist, who responds at a later time. In this modality, there is no real-time interaction between the patient and the dermatologist. This means that the information sent depends on the intervention of a third person (a primary care physician, nurse, or in many studies, a research assistant). E-mail systems or web interfaces may be used, since these technologies allow clinicians to attach and transmit a medical history form with the obligatory fields completed together with digital images of the patient's lesions. The procedure is asynchronous as the teleconsultation (consisting of clinical data and images) is first created and then transmitted. The consultant then evaluates the data and responds, and none of these steps require the specialist to be available at the same time as the consulting parties.

Hybrid systems

Hybrid systems are store-and-forward systems that can also handle real-time interaction. Real-time interaction may take place by way of 2-way audio communication (for example using the Picasso still phone),³ or it may take the form of video conferencing using a webcam.^{8,83} The Swiss Dermanet project also uses a hybrid system to store and forward clinical histological and dermoscopic photographs to enable physicians on the teledermatology network to later discuss cases via a multilateral real-time video conferencing system.^{17,84}

Each system has advantages and disadvantages (Tables 5 to 7). However, most dermatologists tend to prefer the store-and-forward system because it is simpler to coordinate, and because it saves time and economic resources.⁸⁵

The chief advantage of video conferencing is that it is more similar to a traditional face-to-face consultation and it allows interaction between dermatologist, general

Table 5. Differences Between Real-Time Online Teledermatology and Asynchronous Store-and-Forward Systems

<i>Feature</i>	<i>Online Video Conferencing</i>	<i>Store-and-Forward (Asynchronous Teledermatology)</i>
Real time	Yes	No
Possibility of adjusting, retouching, or retaking images	Yes, immediate	No, requires additional transmissions
Clinical information	Complete	Standardized
	Taken by the specialist	Taken by the primary care physician or nursing staff
Response	Immediate	Delayed
	More likely to resolve the problem	Less likely to resolve the problem
Cost	Very high	Low
	Requires broadband connection	Broadband optional
	Requires more time on the part of both professionals and patients	Requires less time on the part of the professionals
Image quality	Possibly adequate but minimal	Very good
Time and place flexibility	No	Yes
Educational contribution	Very good	Good

Sources: Eedy DJ, et al⁴ and Ribera M, et al.⁵

Table 6. Arguments For and Against Store-and-Forward or Asynchronous Teledermatology Systems

<i>For</i>	<i>Against</i>
Cheap and effective for disease diagnosis and management	Impossible to obtain information directly from patients and PCP
Acceptable validity and reliability	Less education for the PCP
Effective for screening and selecting patients for hospitalization	Dehumanizes medical care
A large number of images can be reviewed quickly by the dermatologist	Boring and repetitive for the specialists
Reduces waiting time for initial patient assessment	If the image quality is inadequate, the consultation must be repeated and treatment is delayed

Abbreviation: PCP, primary care physician.

Source: Romero G.²³

physician, and patient. This type of interaction usually makes the consultation more reliable in terms of diagnosis and disease management. The disadvantages of real-time systems are higher cost, greater bandwidth requirements, and, most importantly, the need to bring all the participants together at the same time, a constraint that has been shown to greatly increase the time taken to complete a consultation.

Asynchronous consultations are less costly, require less bandwidth, and use technical equipment that is increasingly more generally available (digital still cameras). Moreover, there is no need to coordinate the simultaneous presence of doctors and patients, another timesaving advantage. Time is always an important consideration, particularly in

the case of patients, physicians, and healthcare administrators. Store-and-forward platforms have evolved with advances in digital imaging and Internet access. Similarly, increasingly faster and more efficient data transmission has been made available by the rapid development of the Internet.⁵¹

Teledermatology Applications

Teledermatology is a system of interpersonal communication between dermatologists located in different places (with links between specialized care facilities and hospitals,

Table 7. Arguments For and Against Real-Time or Interactive Video Conferencing Systems

<i>For</i>	<i>Against</i>
Three-way interactive consultation between the dermatologist, the PCP, and the patient	Scheduling and coordination problems
More effective than asynchronous systems in terms of diagnosis and disease management	Technical faults cause substantial cost in time and money
More comprehensive and better quality clinical information than with asynchronous systems	Lower image quality than in asynchronous systems
Educational value for the PCP	Time spent is similar to conventional consultation
Cost-effective for long distances and when nursing personnel (and not the PCP) attend patients during the teleconsultation	Not cost effective for short distances

Abbreviations: PCP, primary care physician.

Taken from Romero G.²³

between different hospitals located in the same or different communities, and even between different countries), between dermatologists and other clinicians (primary care or specialized physicians), or between dermatologists and their patients.

This technology can be used for training purposes as well as healthcare. As mentioned above, dermatology is a specialty in which diagnosis is essentially based on the observation of lesions and, when necessary, on microscopic observation of these lesions. Diagnosis is normally made by way of a conventional in-person visit, referred to in the literature as a face-to-face consultation. During this visit, which requires the simultaneous presence of the dermatologist and the patient in the same place, a medical history is taken and the patient is examined. Different kinds of visual documentation, such as photographs and slides, can be used to consult with other colleagues in clinical sessions.⁵

Teleconsultation

There are various forms of teleconsultation depending on who is participating. Participants may include the patient, nursing staff, specialized technical personnel, primary care physicians, or all of the above.⁸⁶ Consultation between dermatologists and nursing staff in geriatric institutions can be useful, but the most common form of teleconsultation is between primary care physicians and dermatologists. The availability of paramedical personnel specialized in telemedicine who can take charge of the clinical photography and handle the computer application can help to reduce the workload of the primary care physician.⁵¹ Teleconsultation between dermatologists is used when one of the participants is particularly specialized in the subject matter or when a second opinion is sought. Some authors see this procedure as the future gold standard in diagnosis.⁸⁷ Very often in such cases dermoscopic images and histological images (virtual slides) are attached.⁸⁸ While direct

teleconsultation between patients and dermatologists without the intervention of a trained presenter has been studied^{18,89} this procedure is not recommended as a routine practice because of legal and organizational considerations.

The aim of teleconsultation is always to complement and never to replace conventional face-to-face consultation.⁹⁰ It is particularly useful for screening patients and triage,^{24,91} but is also used for pre- and post-surgical evaluation of skin cancer patients,^{12,92} and to request the opinion of an expert in dermoscopy.⁹³

Education and Training

Teledermatology has excellent applications as a medium for delivering classes to medical students and post graduate courses of different kinds. It is also a useful tool in the continuing education of dermatologists and primary care physicians. As with teleconsultation, when used for these purposes teledermatology can take place in real time, with the possibility of interactive student participation, or recorded transmission may be used. Interactive real-time presentation is by a wide margin the most motivating modality for students and is also more appropriate in terms of teaching methodology.⁵

Of particular interest for educational purposes are web sites for medical students, such as dermatoweb.net, and sites used for continuing education, such as the Austrian www.telederm.org and the Swiss Dermanet.^{94,95} Other valuable resources are the on-line atlases with thousands of clinical images (www.dermatlas.org and the Dermatology Online Atlas on www.dermis.net) and e-learning programs, such as Cyberderm-Doit (www.cyberderm.net) and Dermconsult.com. New technologies, such as virtual reality, can be valuable aids for teaching surgical techniques⁹⁶ and complex anatomical structures.⁹⁷

Some teledermatology applications can be useful in for both healthcare and teaching. Applications used to present

Table 8. Advantages and Disadvantages of Teledermatology

<i>For</i>	<i>Against</i>
More equitable provision of specialized services to remote areas, with access for all citizens	Teledermatology should be a facet of the dermatology service and not just an easy way to alleviate the deficiencies of the healthcare system
Patients can choose a hospital or specialist irrespective of the obstacles imposed by distance	Resistance to change on the part of professionals
The images are as good as those used in conventional face-to-face consultations	Tendency to focus on the presentation of the lesion instead of the patient as a whole. Less emphasis on preventative medicine
Management plans similar to those applied in conventional face-to-face consultations	Over 50% of patients subsequently require a face-to-face consultation
Generally high acceptance on the part of patients	Some patients prefer face-to-face consultation with a dermatologist
Reduces the patients' expenses (for example, travel and lost work time)	Increases the cost to the healthcare system because of the expense of acquiring and maintaining the necessary equipment and infrastructure
Reduces the expense and morbidity associated with incorrect diagnosis and treatment on the part of the PCP	Reduces diagnostic certainty and increases the number of diagnostic errors in specialized care
Saves the specialist's time by obviating the need to travel to other areas	Creates work overload for the PCPs
Shorter waiting lists than for conventional consultation	Demotivates specialists (making them merely a tool of the primary care services)
Increases the interest of PCPs in dermatology	Dehumanizes specialist care
Tool for improving the continuing in-service training of PCPs and specialists	Poses problems relating to data security, privacy, and legal responsibility
Better quality of care than that provided by physicians not specialized in dermatology. Increase in the number of jobs for teledermatologists	Potential reduction in the number of jobs for dermatologists in conventional settings
Improved use of the medical resources in the healthcare system. Avoids duplication and triplication of consultations on primary and specialized care levels	
Continual reductions in the cost of the technology and progressive improvement in the quality and capability of the systems	

Abbreviation: PCP, primary care physician.
Adapted from García Vega FJ.⁴⁵

clinical cases are just one example of this dual functionality. These presentations may be used at medical conferences, allowing participants to discuss cases (an increasingly common format at conferences), or as part of training programs organized for this purpose, or they may simply be used by dermatologists to develop or discuss a diagnosis.¹

Advantages and Disadvantages of Teledermatology

Like any new technique, teledermatology has its supporters and detractors. And, as is usually the case, a more impartial intermediate position allows us to make a more accurate

assessment of the situation and facilitates our understanding of the new technology. Table 8 summarizes the basic arguments in this debate.

Essential Components of Clinical Teledermatology

Conventional dermatological practice requires a careful medical history and an appropriate physical examination, and these elements can be provided by telemedicine systems so long as the medical history and images include all the data necessary for developing a diagnosis and a treatment plan for the patient.

Table 9. Recommendations of the American Telemedicine Association on Photography for Teledermatology

For a generalized rash:
1. Anterior and posterior images of the body to indicate the situation of the involved areas (distribution)
2. Normal examination distance for typical lesions (between 22.86 and 30.48 cm)
3. For certain lesions, very close-up images should be taken with a macro focus lens at a distance of more than 10.16 cm from the surface of the lesion (always identify the area of the body under examination).
For localized rash:
1. Normal distance from subject (between 22.86 and 30.48 cm)
2. In the case of highly localized or individual lesions, use the macro focus lens at a distance of approximately 10.16 cm from the surface of the lesion (always identify the part of the body in the photograph).
General recommendations:
1. Always include a ruler with centimeter markings in the photograph to indicate the size of the lesion
2. Use a blue or gray curtain as a backdrop whenever possible
3. Always use flash even when the natural light is good

Characteristics of the Medical History

A proper medical history should include demographic information, duration of condition, history and description of symptoms, additional relevant or aggravating factors, location and/or distribution of lesions, suspected diagnosis, and prior treatment. General medical information should include information concerning the patient's personal background, current medication and allergies, and any relevant family history. Dermatologists should request more complete information if they consider this might be important.

Asynchronous systems are less flexible and the information must conform to a standardized template. This information will be stored for subsequent retrieval and transmission.^{98,99}

Technical Aspects of Teledermatology

The key to diagnosis is the quality of the images used. This quality is determined by definition, color fidelity, precision framing, and the transmission process. Current technology allows the transmission of images with a resolution similar to that of color slides, which allows a diagnosis to be established in a high percentage of cases.⁵ In early studies, Perednia et al¹⁰⁰ compared the use of conventional slides of

skin lesions and digitalized images at different resolutions and found a good statistical correlation between the slides and 24-bit color 574 × 489 pixel digital images. Bittorf et al¹⁰¹ later established in 1997 that 24-bit color 768 × 512 pixel images are perceived as equivalent to images at higher resolutions. Digital photography has advantages over film because it offers easy access and many possibilities for image manipulation.

Good images can be obtained using a resolution of 1024 × 744 pixels or even 768 × 512 pixels when the photograph is taken at the appropriate distance. However, when higher resolutions are used (1280 × 1024 pixels), details can be enlarged on the screen without any loss of quality.¹⁰² The following specifications are considered by Pak¹⁰³ to be optimal for a digital camera intended for use in teledermatology: a resolution of 2048 × 1536 pixels with a 24-bit color depth (16.7 million colors or Truecolor); optical zoom with enlargement of at least 3 ×; through-the-lens dedicated flash; macro focus mode (which allows perfect focus at distances between 10 and 30 cm); and the option of image compression using the JPEG (Joint Photographic Expert Group) standard. A wide variety of low-cost cameras on the market fulfill all these requirements. Minimum specifications for visualizing quality images are met by medium range digital still cameras and standard digital video cameras.

The resolution of an asynchronous system is generally 3 times that of analogue videos. Moreover, real-time video conferencing requires a bandwidth of at least 384 Kbps. ISDN connections support 144 Kbps, and T1 lines may reach a speed of 1544 Kbps. Store-and-forward systems require only 56 Kbps, and acceptable transmission at these speeds can be achieved with most conventional telephone lines. The cost of real-time video using a broadband connection is approximately 6 times that of using an asynchronous store-and-forward platform.¹⁰³ A fast broadband connection, such as ADSL, cable, or dedicated T1, T2, T3, and T4 lines, is recommended for the routine use of asynchronous teledermatology. However, conventional telephone lines may be used in areas where these systems are not available.

In order to standardize the transmission of medical data, the American Telemedicine Association has established a protocol for the acquisition of images for use in teledermatology (Table 9) and guidelines relating to the additional data that must be attached to each image to identify the patient and the site of the lesions.

Characteristics of the Consultation

Regardless of the modality used for the teleconsultation, it is essential to ensure patient privacy, data security, and a level of simplicity that will ensure the reproducibility of the process. Although it may be considered sufficient that the

patient be reasonably informed and give oral consent, the recommended procedure is to obtain a signed informed consent form,⁵ especially if the patient can be recognized from the photograph. The use of recognizable photographs should be avoided when possible, but this is not always feasible. In the case of real-time teledermatology, minimal conditions of privacy, comfort, lighting, and an appropriate physical space are essential.³ These requirements are less important for asynchronous consultations, which only require an appropriate photographic technique and procedure. To facilitate the consultation, teledermatology protocols should be carefully explained to the patient before the start of a video session. The personnel (primary care physicians, nurses, and technicians) must receive appropriate training since their role is to be the hands and ears of the dermatologist. The staff involved in the process should all be properly trained and need not always be physicians; nurses and qualified paramedical healthcare staff may also present the teleconsultation.^{30,104}

In over 50% of cases, the consultation may not be completed using telemedicine alone. It is, therefore, essential not to consider telemedicine as the only option, but rather as a technique that complements conventional face-to-face consultation. Face-to-face consultation may be deemed necessary because of difficulties in diagnosis (complex cases, the need for palpation, or difficulties in obtaining quality images), or the need for additional investigations or treatments that can only be performed in a hospital setting (cryotherapy, biopsies, surgery, etc).^{29,30}

Legal and Organizational Aspects

The organization of a teledermatology system is as complex as any activity involving coordination between different levels of the healthcare system. All the professionals involved require special training and must, obviously, accept their role within the system. Appropriate investment is required to implement a teledermatology system, and time must be allocated specifically for all of these activities. Although these recommendations may appear rather obvious, quite a few telemedicine programs have failed because these indispensable requirements were not fulfilled.^{20,23}

Secure access is another very important aspect that must be taken into account.⁵ Cryptography in the secure transmission of electronic data deals with the 3 key aspects that lie at the center of the so called security onion: confidentiality, identification-authenticity, and integrity of the data.¹⁰⁵ Compliance with current legislation regulating the privacy of sensitive data (since medical records are always considered sensitive) involves the following key points: the use of secure protocols (https), user and password authentication, traceability of access, and the preferred use of intranets rather than open networks.¹⁰⁶ In any case, both American¹⁰⁷ and European⁹⁰ legislation allows medical data

to be shared between colleagues when the objective is the care of the patient.¹⁶ When the material is for use in medical training or education, explicit consent is required from the patient whose photographs or data are used.¹⁷

As an emerging technology, the use of teleconsultation poses legal problems that must be resolved.^{108,109} However, it is not considered that these aspects represent an obstacle to the implementation of telemedicine systems.¹¹⁰ The central debate is focused on deciding which party is ultimately responsible for the consultation carried out using this system, in the case of both the diagnosis and the treatment of the patient.¹⁰³ In this respect, the telemedicine consultation does not differ from the conventional management model. It consists of clinical advice given by the specialist to the consulting physician and the latter continues to be responsible for the care, diagnosis, and treatment of the patient.^{17,111}

The question of how to invoice teledermatology services is a problem common to both public and private care providers. In private medicine, telemedicine is included in the fee schedules, and this has been the case since 2000 in the United States of America. Medicare insurance covers teleconsultations via video conferencing systems in all rural areas of the country and asynchronous consultations with Hawaii and Alaska.^{16,31} In public medicine, it is the task of administrators to quantify this activity and allocate time for the work involved to both the primary care physician and the dermatologist. Failure to do this will lead inevitably to work overload and the eventual failure of the telemedicine system.⁷ Perhaps the main obstacle in private medicine is the need for insurance coverage for malpractice.³¹ One final aspect that should be taken into account is whether physicians can be obliged to undertake teledermatology as another routine medical task in their working day, or whether the use of teledermatology should be voluntary.⁵ Most medical centers choose the second option because it is the only way to ensure the proper functioning of the system.

Conflicts of Interest

The authors declare no conflicts of interest.

References

1. Stanberry B. Telemedicine: barriers and opportunities in the 21st century. *J Intern Med.* 2000;247:615-28.
2. Telemedicine: fad or future? *Lancet.* 1995;345:73-4.
3. Burdick AE, Berman B. Teledermatology. *Adv Dermatol.* 1997;12:19-45.
4. Eedy DJ, Wootton R. Teledermatology: a review. *Br J Dermatol.* 2001;144:696-707.
5. Ribera M, Peñas PF, Barco L. La teledermatología hoy. *Piel.* 2001;16:225-37.
6. Wootton R, Darkins A. Telemedicine and the doctor-patient relationship. *J R Coll Physicians Lond.* 1997;31:598-9.

7. Larsen F, Gjerdrum E, Obstfelder A, Lundvoll L. Implementing telemedicine services in northern Norway: barriers and facilitators. *J Telemed Telecare*. 2003;9 Suppl 1:S17-8.
8. Romero G, García M, Vera E, Martínez C, Cortina P, Sánchez P, et al. Resultados preliminares de DERMATEL: estudio aleatorizado prospectivo comparando modalidades de teledermatología síncrona y asíncrona. *Actas Dermosifiliogr*. 2006;97:630-6.
9. Martínez-García S, Boz-González J, Martín-González T, Samaniego-González E, Crespo-Erchiga V. Teledermatología. Revisión de 917 teleconsultas. *Actas Dermosifiliogr*. 2007;98:318-24.
10. Wootton R, Bloomer SE, Corbett R, Eedy DJ, Hicks N, Lotery HE, et al. Multicentre randomised control trial comparing real time teledermatology with conventional outpatient dermatological care: societal cost-benefit analysis. *BMJ*. 2000;320:1252-6.
11. Harrison PV, Kirby B, Dickinson Y, Schofield R. Teledermatology—high technology or not? *J Telemed Telecare*. 1998;4 Suppl 1:31-2.
12. Moreno-Ramírez D, Ferrándiz L, Nieto-García A, Carrasco R, Moreno-Álvarez P, Galdeano R, et al. Store-and-forward teledermatology in skin cancer triage: experience and evaluation of 2009 teleconsultations. *Arch Dermatol*. 2007;143: 479-84.
13. Eysenbach G, Diepgen TL. Patients looking for information on the Internet and seeking teledvice: motivation, expectations, and misconceptions as expressed in e-mails sent to physicians. *Arch Dermatol*. 1999;135:151-6.
14. Jadad AR, Sigouin C, Cocking L, Booker L, Whelan T, Brownman G. Internet use among physicians, nurses, and their patients. *JAMA*. 2001;286:1451-2.
15. Gutiérrez G. Medicare, the Internet, and the future of telemedicine. *Crit Care Med*. 2001;29:N144-50.
16. Dill SW, Digiovanna JJ. Changing paradigms in dermatology: information technology. *Clin Dermatol*. 2003;21: 375-82.
17. Burg G, Hasse U, Cipolat C, Kropf R, Djamei V, Soyer HP, et al. Teledermatology: just cool or a real tool? *Dermatology*. 2005;210:169-73.
18. Eminovic N, Witkamp L, Ravelli AC, Bos JD, van den Akker TW, Bousema MT, et al. Potential effect of patient assisted teledermatology on outpatient referral rates. *J Telemed Telecare*. 2003;9:321-7.
19. Hersh W, Hickam D, Severance S, Dana T, Krages K, Helfand M. Telemedicine for the medicare population: update. *AHRQ No. 06-E007*. 2006.
20. English JS, Eedy DJ. Has teledermatology in the U.K. finally failed? *Br J Dermatol*. 2007;156:411.
21. Neuse WH, Neumann NJ, Lehmann P, Jansen T, Plewig G. The history of photography in dermatology. Milestones from the roots to the 20th century. *Arch Dermatol*. 1996;132: 1492-8.
22. Ratner D, Thomas CO, Bickers D. The uses of digital photography in dermatology. *J Am Acad Dermatol*. 1999;41: 749-56.
23. Romero G. *Fiabilidad de la teleconsulta en Dermatología [doctoral thesis]*. Madrid: Facultad de Medicina. Universidad Complutense de Madrid; 2007.
24. Taylor P, Goldsmith P, Murray K, Harris D, Barkley A. Evaluating a telemedicine system to assist in the management of dermatology referrals. *Br J Dermatol*. 2001; 144:328-33.
25. Hersh W, Helfand M, Wallace J, Kraemer D, Patterson P, Shapiro S, et al. A systematic review of the efficacy of telemedicine for making diagnostic and management decisions. *J Telemed Telecare*. 2002;8:197-209.
26. Knol A, van den Akker TW, Damstra RJ, de Haan J. Teledermatology reduces the number of patient referrals to a dermatologist. *J Telemed Telecare*. 2006;12:75-8.
27. Whited JD. Teledermatology research review. *Int J Dermatol*. 2006;45:220-9.
28. Eminovic N, de Keizer NF, Bindels PJ, Hasman A. Maturity of teledermatology evaluation research: a systematic literature review. *Br J Dermatol*. 2007;156:412-9.
29. Kvedar JC, Edwards RA, Menn ER, Mofid M, González E, Dover J, et al. The substitution of digital images for dermatologic physical examination. *Arch Dermatol*. 1997;133:161-7.
30. Zelickson BD, Homan L. Teledermatology in the nursing home. *Arch Dermatol*. 1997;133:171-4.
31. Pak H. Teledermatology in North America. *Curr Probl Dermatol*. 2003;32:222-5.
32. Lyon CC, Harrison PV. Digital imaging and teledermatology: educational and diagnostic applications of a portable digital imaging system for the trainee dermatologist. *Clin Exp Dermatol*. 1997;22:163-5.
33. Williams HC. Increasing demand for dermatological services: how much is needed? *J R Coll Physicians Lond*. 1997;31: 261-2.
34. Du Moulin MF, Bullens-Goessens YI, Henquet CJ, Brunenberg DE, de Bruyn-Geraerds DP, Winkens RA, et al. The reliability of diagnosis using store-and-forward teledermatology. *J Telemed Telecare*. 2003;9:249-52.
35. Jemec GB, Thorsteinsdottir H, Wulf HC. The changing referral pattern in Danish dermatology—Rigshospitalet, Copenhagen, 1986-1995. *Int J Dermatol*. 1997;36:453-6.
36. Ramsay DL, Fox AB. The ability of primary care physicians to recognize the common dermatoses. *Arch Dermatol*. 1981; 117:620-2.
37. Clark RA, Rietschel RL. The cost of initiating appropriate therapy for skin diseases: a comparison of dermatologists and family physicians. *J Am Acad Dermatol*. 1983;9:787-96.
38. Pariser RJ, Pariser DM. Primary care physicians' errors in handling cutaneous disorders. A prospective survey. *J Am Acad Dermatol*. 1987;17:239-45.
39. Krupinski EA, LeSueur B, Ellsworth L, Levine N, Hansen R, Silvis N, et al. Diagnostic accuracy and image quality using a digital camera for teledermatology. *Telemed J*. 1999; 5:257-63.
40. Perednia DA, Wallace J, Morrisey M, Bartlett M, Marchionda L, Gibson A, et al. The effect of a teledermatology program on rural referral patterns to dermatologists and the management of skin disease. *Medinfo*. 1998;9 Pt 1:290-3.
41. Oakley AM. Teledermatology in New Zealand. *J Cutan Med Surg*. 2001;5:111-6.
42. Jorizzo JL, Phillips CM, Balch DC, Schanz SJ, Branigan AE. Teledermatology: Issues in remote diagnosis and management of cutaneous disease. *Curr Probl Dermatol*. 2002; 14:5-38.
43. Lyon CC, Harrison PV. A portable digital imaging system in dermatology: diagnostic and educational applications. *J Telemed Telecare*. 1997;3 Suppl 1:81-3.
44. Cipolat C, Geiges M. The history of telemedicine. *Curr Probl Dermatol*. 2003;32:6-11.

45. García Vega FJ. Teledermatología, store-and-forward. Santiago de Compostela: Servicio Galego de Saude. Axencia de Avaliación de tecnoloxías sanitarias de Galicia, avalia-t; Informe: INF2003/03 2003.
46. Moser PL, Hauffe H, Lorenz IH, Hager M, Tiefenthaler W, Lorenz HM, et al. Publication output in telemedicine during the period January 1964 to July 2003. *J Telemed Telecare*. 2004;10:72-7.
47. Murphy RL, Jr., Fitzpatrick TB, Haynes HA, Bird KT, Sheridan TB. Accuracy of dermatologic diagnosis by television. *Arch Dermatol*. 1972;105:833-5.
48. Bergmo TS. A cost-minimization analysis of a realtime teledermatology service in northern Norway. *J Telemed Telecare*. 2000;6:273-7.
49. Lamminen H, Tuomi ML, Lamminen J, Uusitalo H. A feasibility study of realtime teledermatology in Finland. *J Telemed Telecare*. 2000;6:102-7.
50. Loane MA, Corbett R, Bloomer SE, Eedy DJ, Gore HE, Mathews C, et al. Diagnostic accuracy and clinical management by realtime teledermatology. Results from the Northern Ireland arms of the UK Multicentre Teledermatology Trial. *J Telemed Telecare*. 1998;4:95-100.
51. Burg G. Store-and-forward teledermatology. e-medicine 2005. Available from: <http://www.emedicine.com/derm/topic560.htm>
52. Whitten PS. Teledermatology delivery modalities: real time versus store and forward. *Curr Probl Dermatol*. 2003;32: 24-31.
53. Kvedar JC. Teledermatology. e-medicine. 2005. Available from: <http://www.emedicine.com/derm/topic527.htm>
54. Hailey D. Some successes and limitations with telehealth in Canada. *J Telemed Telecare*. 2001;7 Suppl 2:73-5.
55. Freeman K, Wynn-Jones J, Groves-Phillips S, Lewis L. Teleconsulting: a practical account of pitfalls, problems and promise. Experience from the TEAM project group. *J Telemed Telecare*. 1996;2 Suppl 1:1-3.
56. Perednia DA. Fear, loathing, dermatology, and telemedicine. *Arch Dermatol*. 1997;13:151-5.
57. Finch TL, Mair FS, May CR. Teledermatology in the UK: lessons in service innovation. *Br J Dermatol*. 2007;156: 521-7.
58. Lim AC, Egerton IB, Shumack SP. Australian teledermatology: the patient, the doctor and their government. *Australas J Dermatol*. 2000;41:8-13.
59. Lawton S, Timmons S. The relationship between technology and changing professional roles in health care: A case-study in teledermatology. *Stud Health Technol Inform*. 2006;122: 669-71.
60. Aas IH. Learning in organizations working with telemedicine. *J Telemed Telecare*. 2002;8:107-11.
61. Aas IH. Telemedicine and changes in the distribution of tasks between levels of care. *J Telemed Telecare*. 2002; 8 Suppl 2:1-2.
62. Perednia DA, Brown NA. Teledermatology: one application of telemedicine. *Bull Med Libr Assoc*. 1995;83:42-7.
63. Ministerio de Sanidad y Consumo. Plan de telemedicina del INSALUD. Madrid: Insalud; 2000.
64. Canto-Neguillo F. Telemedicina: informe de evaluación y aplicaciones en Andalucía. Sevilla: AETSA; 2000.
65. Casanova JM, Sole MB, Marti RM, Baradad M, Riba D, Freixanet P. Teledermatología. *Med Cutan Iber Lat Am*. 2005;33:53-64.
66. Thomas JD, Greenberg NL, García MJ. Digital echocardiography 2002: now is the time. *J Am Soc Echocardiogr*. 2002;15:831-8.
67. Rosenfeld BA, Dorman T, Breslow MJ, Pronovost P, Jenckes M, Zhang N, et al. Intensive care unit telemedicine: alternate paradigm for providing continuous intensivist care. *Crit Care Med*. 2000;28:3925-31.
68. Baker SR, Festa S. The use of teleradiology in an emergency setting with speculation on the near future. *Radiol Clin North Am*. 1999;37:1035-44.
69. Thrall JH. Teleradiology. Part I. History and clinical applications. *Radiology*. 2007;243:613-7.
70. Thrall JH. Teleradiology. Part II. Limitations, risks, and opportunities. *Radiology*. 2007;244:325-8.
71. Leinweber B, Massone C, Kodama K, Kaddu S, Cerroni L, Haas J, et al. Teledermatopathology: a controlled study about diagnostic validity and technical requirements for digital transmission. *Am J Dermatopathol*. 2006;28:413-6.
72. Massone C, Peter SH, Lozzi GP, Di Stefani A, Leinweber B, Gabler G, et al. Feasibility and diagnostic agreement in teledermatopathology using a virtual slide system. *Hum Pathol*. 2007;38:546-54.
73. Coma del Corral MJ, Sánchez MA, Gutiérrez MC, Conde AF, Ramírez M. Panorama actual de la teledermatopatología. *Monogr Dermatol*. 2006;19:393-7.
74. Hersh W, Wallace J, Patterson P, Shapiro SE, Kraemer DF, Eilers GM, et al. Telemedicine for the Medicare population. *Evid Rep Technol Assess (Summ)*. 2001;1-6.
75. Moreno-Ramírez D, Ferrándiz L, Bernal AP, Duran RC, Martin JJ, Camacho F. Teledermatology as a filtering system in pigmented lesion clinics. *J Telemed Telecare*. 2005;11: 298-303.
76. González F, Iglesias R, Suárez A, Gómez-Ulla F, Pérez R. Teleophthalmology link between a primary health care centre and a reference hospital. *Med Inform Internet Med*. 2001;26:251-63.
77. Goldschmidt L. Telemedicine and information technology at the Veterans Administration Palo Alto Health Care System: serving patient care. *Eff Clin Pract*. 1998;1:87-9.
78. Norton SA, Burdick AE, Phillips CM, Berman B. Teledermatology and underserved populations. *Arch Dermatol*. 1997;133:197-200.
79. Burg G, Denz M. The Telemedical Information Society: doctors' playground or a contribution to the evolution of healthcare? *Curr Probl Dermatol*. 2003;32:2-5.
80. Ferguson J. How to do a telemedical consultation. *J Telemed Telecare*. 2006;12:220-7.
81. Haffner A, Zepter K. The communication revolution goes on—global high-speed networks: setting the pace for future multimedia applications. *Curr Probl Dermatol*. 2003;32: 12-6.
82. Massone C, Lozzi GP, Wurm E, Hofmann-Wellenhof R, Schoellnast R, Zalaudek I, et al. Cellular phones in clinical teledermatology. *Arch Dermatol*. 2005;141:1319-20.
83. Baba M, Seckin D, Kapdagli S. A comparison of teledermatology using store-and-forward methodology alone, and in combination with Web camera videoconferencing. *J Telemed Telecare*. 2005;11:354-60.
84. Kuhn L, Milesi L. Dermanet—a tailor-made tool for teledermatology. *Curr Probl Dermatol*. 2003;32:154-7.
85. Granlund H, Thoden CJ, Carlson C, Harno K. Realtime teleconsultations versus face-to-face consultations in

- dermatology: immediate and six-month outcome. *J Telemed Telecare*. 2003;9:204-9.
86. Oakley AM, Rennie MH. Retrospective review of teledermatology in the Waikato, 1997-2002. *Australas J Dermatol*. 2004;45:23-8.
 87. Lozzi GP, Soyer HP, Massone C, Micantonio T, Kraenke B, Fagnoli MC, et al. The additive value of second opinion teleconsulting in the management of patients with challenging inflammatory, neoplastic skin diseases: a best practice model in dermatology? *J Eur Acad Dermatol Venereol*. 2007;21:30-4.
 88. Piccolo D, Smolle J, Argenziano G, Wolf IH, Braun R, Cerroni L, et al. Teledermoscopy—results of a multicentre study on 43 pigmented skin lesions. *J Telemed Telecare*. 2000;6:132-7.
 89. Qureshi AA, Brandling-Bennett HA, Giberti S, McClure D, Halpern EF, Kvedar JC. Evaluation of digital skin images submitted by patients who received practical training or an online tutorial. *J Telemed Telecare*. 2006;12:79-82.
 90. Moreno D, Ferrándiz L, Ruiz A, Nieto A. Teledermatología. Metodología de trabajo y aplicaciones. Monografías de dermatología. 2006;19:348-55.
 91. Van den Akker TW, Reker CH, Knol A, Post J, Wilbrink J, van der Veen JP. Teledermatology as a tool for communication between general practitioners and dermatologists. *J Telemed Telecare*. 2001;7:193-8.
 92. Ferrándiz L, Vázquez F, Moreno-Ramírez D. Teleconsulta prequirúrgica en pacientes con cáncer de piel. *Monogr Dermatol*. 2006;19:378-85.
 93. Braun RP, Meier M, Pelloni F, Ramelet AA, Schilling M, Tapernoux B, et al. Teledermoscopy in Switzerland: a preliminary evaluation. *J Am Acad Dermatol*. 2000;42 (5 Pt 1):770-5.
 94. Cipolat C, Bader U, Ruffli T, Burg G. Teledermatology in Switzerland. *Curr Probl Dermatol*. 2003;32:257-60.
 95. Massone C, Soyer HP, Hofmann-Wellenhof R, Di Stefani A, Lozzi GP, Gabler G, et al. Two years' experience with Web-based teleconsulting in dermatology. *J Telemed Telecare*. 2006;12:83-7.
 96. Gladstone HB, Raugi GJ, Berg D, Berkley J, Weghorst S, Ganter M. Virtual reality for dermatologic surgery: virtually a reality in the 21st century. *J Am Acad Dermatol*. 2000;42:106-12.
 97. Vartanian AJ, Holcomb J, Ai Z, Rasmussen M, Tardy ME, Thomas JR. The virtual nose: a 3-dimensional virtual reality model of the human nose. *Arch Facial Plast Surg*. 2004;6:328-33.
 98. Oakley A. Telemedicine for the new century. *N Z Med J*. 1998;111:354-5.
 99. Whited JD, Hall RP, Simel DL, Foy ME, Stechuchak KM, Drugge RJ, et al. Reliability and accuracy of dermatologists' clinic-based and digital image consultations. *J Am Acad Dermatol*. 1999;41:693-702.
 100. Perednia DA, Gaines JA, Butruille TW. Comparison of the clinical informativeness of photographs and digital imaging media with multiple-choice receiver operating characteristic analysis. *Arch Dermatol*. 1995;131:292-7.
 101. Bittorf A, Fartasch M, Schuler G, Diepgen TL. Resolution requirements for digital images in dermatology. *J Am Acad Dermatol*. 1997;37:195-8.
 102. Lim AC, Egerton IB, See A, Shumack SP. Accuracy and reliability of store-and-forward teledermatology: preliminary results from the St George Teledermatology Project. *Australas J Dermatol*. 2001;42:247-51.
 103. Pak HS. Teledermatology and teledermatopathology. *Semin Cutan Med Surg*. 2002;21:179-89.
 104. Williams TL, Esmail A, May CR, Griffiths CE, Shaw NT, Fitzgerald D, et al. Patient satisfaction with teledermatology is related to perceived quality of life. *Br J Dermatol*. 2001;145:911-7.
 105. Boesch H, Airaghi G. Secure transfer of medical data over the Internet: from regulatory data protection jam to framework-based requirements. *Curr Probl Dermatol*. 2003;32:71-5.
 106. Puig L. Confidencialidad y seguridad informática en dermatología. *Piel*. 1999;14:128-32.
 107. Kibbe DC. What you need to know about HIPAA now. *Fam Pract Manag*. 2001;8:43-7.
 108. Silverman RD. Current legal and ethical concerns in telemedicine and e-medicine. *J Telemed Telecare*. 2003; 9 Suppl 1:S67-9.
 109. Callens S. Telemedicine and European law. *Med Law*. 2003; 22:733-41.
 110. Wallace S, Sibson L, Stanberry B, Waters D, Goodall P, Jones R, et al. The legal and risk management conundrum of telemedicine. *J Telemed Telecare*. 1999;5 Suppl 1:S8-9.
 111. García A, Paseiro E, García A, Bugarin R. Accesibilidad de servicios y telemedicina. Aplicación informática de telemedicina asistencial del Servicio Gallego de Salud. *Todo Hosp*. 2002;191:676-83.