Elsevier Editorial System(tm) for International Journal of Medical Informatics
Manuscript Draft

Manuscript Number: IJMI-D-11-00190R2

Title: Lessons Learned after a Three-Year Store and Forward Teledermatology Experience using Internet: Strengths and Limitations

Article Type: Original Article

Keywords: teledermatology, store and forward, telemedicine, concordance evaluation, pediatrics dermatology,alignment

Corresponding Author: Mrs Nelia Lasierra,

Corresponding Author's Institution:

First Author: Nelia Lasierra

Order of Authors: Nelia Lasierra; Álvaro Alesanco; Yolanda Gilaberte; Rosa Magallón; José García

Abstract: Purpose
This paper presents a three-year teledermatology evaluation experience. The aim is to explain the methodology followed, present the evaluation results, discuss critically the issues that emerged during the experience and report the main lessons learned.

Methods
A complete design and evaluation methodology was conducted to fully address significant issues arising from other previous teledermatology experiences. (1,2) System-design requirements and image quality issues were studied. (3) A detailed clinical concordance study was undertaken in order to determine the accuracy of diagnoses made using teledermatology in order to assess different dermatological clinics. (4) Finally, an impact study on the health system was performed. Then, clinical, technical, social and alignment outcomes were analysed during the study and at the end of the experience in order to understand how emerging factors affected the final setup of the teledermatology system.

Results
The most important results reported in this study can be summarized as follows. (1) A complete web-based environment for teledermatology support was developed as a result of a dynamic evaluation process with clinical personnel. (2) A total of 120 teleconsultations (82 pediatric and 28 adult) were made during the clinical concordance study. Concordance analysis was carried out for each dermatological disease group. High concordance rates were found in pediatrics for inflammatory dermatoses (76%) and also for adults (75%) with infections and infestations. (3) Physicians were satisfied with the teledermatology system but the time dedicated to consultation in primary care was a limiting factor (19 minutes for each teleconsultation) (4) An extensive discussion about the successful and the limiting aspects of the teledermatology experience revealed the reasons behind the final decision not to proceed with its implementation. It was considered not to be aligned with Health Care Organization (HCO) strategy and consequently did not achieve high-level support for its long-term implementation.

Conclusions

A high degree of diagnostic accuracy both for pediatric and adult consultations was achieved using the teledermatology system with affordable technical requirements. Its usefulness for filtering dermatological referrals was also demonstrated in the study. Nevertheless, other factors such as the reorganization required for the physicians' time schedule, remuneration issues, absence EHR (electronic health record) integration and lack of interaction with the HCO were important limiting factors. This led to the conclusion that under the evaluation conditions long-term set-up was not possible. It was also concluded that HCO participation would have been essential for both the evaluation study and the long-term set-up of the system.

Title: Lessons Learned after a Three-Year Store and Forward Teledermatology Experience using Internet: Strengths and Limitations

N. Lasierra*, A. Alesanco*, Y. Gilaberte†, R. Magallón††, J. García*

* Communications Technologies Group (GTC). Aragón Institute of Engineering Research (I3A). University of Zaragoza, Spain,{nelia.lasierra,alesanco, jogarmo}@unizar.es

† Section of Dermatology, San Jorge Hospital (Huesca), Spain, ygilaberte@salud.aragon.es

†† Health Science of Aragón Institute, Zaragoza, Spain, med000764@gmail.com

Contact: Nelia Lasierra, Communications Technologies Group, CPS, University of Zaragoza, C/María de Luna Ed. Ada Byron. 50018 Zaragoza (Spain)

Telf: 0034976762698

Email: nelia.lasierra@unizar.es

Keywords: teledermatology, store and forward, telemedicine, concordance evaluation, pediatrics dermatology, alignment.

Structured Abstract

Purpose

This paper presents a three-year teledermatology evaluation experience. The aim is to explain the methodology followed, present the evaluation results, discuss critically the issues that emerged during the experience and report the main lessons learned.

Methods

A complete design and evaluation methodology was conducted to fully address significant issues arising from other previous teledermatology experiences. (1,2) System-design requirements and image quality issues were studied. (3) A detailed clinical concordance study was undertaken in order to determine the accuracy of diagnoses made using teledermatology in order to assess different dermatological clinics. (4) Finally, an impact study on the health system was performed. Then, clinical, technical, social and alignment outcomes were analysed during the study and at the end of the experience in order to understand how emerging factors affected the final setup of the teledermatology system.

Results

The most important results reported in this study can be summarized as follows. (1) A complete web-based environment for teledermatology support was developed as a result of a dynamic evaluation process with clinical personnel. (2) A total of 120 teleconsultations (82 pediatric and 28 adult) were made during the clinical concordance study. Concordance analysis was carried out for each dermatological disease group. High concordance rates were found in pediatrics for inflammatory dermatoses (76%) and also for adults (75%) with infections and infestations. (3) Physicians were satisfied with the teledermatology system but the time dedicated to consultation in primary care was a limiting factor (19 minutes for each teleconsultation) (4) An extensive discussion

about the successful and the limiting aspects of the teledermatology experience revealed the reasons behind the final decision not to proceed with its implementation. It was considered not to be aligned with Health Care Organization (HCO) strategy and consequently did not achieve high-level support for its long-term implementation.

Conclusions

A high degree of diagnostic accuracy both for pediatric and adult consultations was achieved using the teledermatology system with affordable technical requirements. Its usefulness for filtering dermatological referrals was also demonstrated in the study. Nevertheless, other factors such as the reorganization required for the physicians' time schedule, remuneration issues, absence EHR (electronic health record) integration and lack of interaction with the HCO were important limiting factors. This led to the conclusion that under the evaluation conditions long-term set-up was not possible. It was also concluded that HCO participation would have been essential for both the evaluation study and the long-term set-up of the system.

Body of the manuscript

1. Introduction

Telemedicine systems today are widely used for delivering dermatological services to remote areas, especially in countries where there is no easy access to dermatology care due to geographical barriers or a widely dispersed distribution of dermatologists [1, 2]. Using teledermatology, GPs (general practitioners) are able to refer consultations to a dermatologist located elsewhere using information and communication technologies.

In general, there are two main ways of delivering teledermatology [3]. The first is based on videoconferencing systems providing real-time and live-interactive communication between GP, patient and dermatologist [4, 5]. The second is based on taking digital images of skin lesions and sending them through the Internet from a primary care centre (GP and patient location) to a secondary care centre (dermatologist location)[1,2,6-12]. This is known as store-and-forward teledermatology (S&F). These systems do not require real-time interaction between the parties, and are less financially and technologically demanding than real-time setups. In general, real-time is seldom required for teledermatology while S&F provides sufficient flexibility in consultation schedules with high rates of accuracy [7,11,12]. For these reasons most teledermatology experiences reported in recent years are based on S&F systems.

The interest in using telemedicine to send medical images for remote diagnosis is not new. As a matter of fact, it started with teleradiology in the early 1960s [13,14]. Teleradiology is one of the more successful telemedicine applications and recent reported experiences show that it continues to be used today [15]. Teledermatology adopts many of the ideas developed for teleradiology and adapts them to the peculiarities of dermatological images. Therefore, the S&F architectures developed for teleradiology can be easily adapted to teledermatology. See for example [16, 17] where

S&F teleradiology systems are presented. These systems would be able to support dermatological images after making the appropriate modifications. Furthermore, the challenge of seamless integration with facility-based picture archiving and communication system (PACS) in hospitals studied for years for teleradiology applications [18] could be compared to the main challenges presented by the integration of teledermatology applications in hospitals. The main differences between these closely related telemedicine disciplines, which could be jointly implemented over the same architecture to provide collaborative services, are their degrees of accessibility resulting from the different devices used to obtain the images in either case. While teleradiology needs expensive digital film scanners only available in hospitals, teledermatology merely requires a digital camera, very affordable for small medical centres. Nevertheless, there has been some research carried out into the use of low-cost cameras in teleradiology systems [19].

The great interest in teledermatology is demonstrated by a plethora of experiences reported in recent decades [1-12, 20-26]. Different kinds of teledermatology studies can be found in the literature concerning the different aspects involved in a teledermatology system setup. Such aspects include teledermatology effectiveness and diagnosis reliability [2,7,10-11,20], efficacy for GPs learning [8], patients and physicians' acceptability [21, 22], and time scheduling [9]. Other reviews or comparative studies [3,23,24,26] have reported low-cost successful experiences [10] or experiences detailing the main problems detected in daily routine consultations [2]. The use of teledermatology for diagnosis in general dermatological clinics has been addressed in some previous studies [7, 10], and there are also studies dealing specifically with pediatrics [12, 20]. It is interesting to note that teledermatology has been broadly studied for the diagnosis of skin cancer conditions and has been shown to be a valuable

complementary tool in primary care centres as a filtering tool for pigmented skin referrals [6].

The great majority of these studies focus on showing teledermatology as a valuable tool for medical practice but they do not give much consideration to the long term implementation of these systems within the clinical routine of healthcare centres [1,2,5-12,20-22,25]. The alignment of new information systems with the objectives of Health Care Organizations (HCO) is a key factor for their introduction and long-term success. Alignment theories should thus be taken into account when examining the long-term implementation of a teledermatology system [27,28].

Alignment theories suggest that as long as a telemedicine system contributes to the achievement of HCO objectives following defined strategic plans, it can be aligned with hospital strategy and its long-term set-up will be possible. Bush *et. al.* in [29] suggested five steps for aligning information systems with organizational objectives: 1) identify organization objectives; 2) identify organization strategy to cope with the objectives; 3) envision an information system to support organization strategies; 4) gain approval of health centres at a high-level to implement the system; 5) implement the system.

The present paper describes a teledermatology experience initiated three years ago by a group of volunteers from 3 different disciplines (dermatologists, GPs and engineers) in order to propose solutions for improving the dermatology service in the Spanish region of Aragón. The initiative arose when some GPs hypothesized that by using a teledermatology system many referrals to specialist hospitals could be avoided and others could be done much more quickly (in urgent cases). Hence, it was thought that a teledermatology system could help to improve patient care by speeding up the initial contact of patients with the dermatologist (Steps 1 and 2 of the 5 proposed in [29]). HCO approval is crucial for the long-term working of such a service. Thus, our main

goal was to demonstrate the usefulness of a teledermatology service in order to gain HCO approval and achieve its long-term implementation. Our study concentrated on obtaining real evidence of the potential usefulness of the teledermatology system in our region with its particular circumstances.

In order to envision and implement the system, in accordance with Step 3 of the alignment process [29], we took into account lessons learned from other experiences in our methodology study. After reviewing all the experiences mentioned above [1-12, 20-26], it was clear that there were some important points requiring careful consideration when developing a useful teledermatology system. We finally identified 4 relevant factors that had to be successfully handled during the study relating to the design and development requirements and evaluation of the system: (1) the teledermatology software system had to be user-friendly and focused on physicians' skills and requirements, (2) digital photographs of dermatological lesions had to be of high quality and the teledermatology system equipped with image analysis tools, (3) a clinical concordance study needed to be carried out in order to determine what dermatological lesions the system could be useful for, (4) an impact study on the health system had to be undertaken in order to evaluate the long-term viability of the system.

Different problems (technical, organizational and social) did eventually emerge during the study and finally a long-term setup of the system was not possible. A retrospective assessment of the project as a whole together with the results was therefore carried out after the three-year experience in order to identify the main problems and analyse any benefits that could be derived. Although many teledermatology experiences have been reported to date, the value of this particular document is that it not only describes how the system was developed and main outcomes of its evaluation but it also discusses the strengths and limitations of the system in a realistic manner.

The remainder of this paper is organized as follows. The methods section describes in detail the methodology followed in designing and evaluating the system. The results section then reports the main outcomes with specific reference to the four relevant factors mentioned above. The results of the evaluation are then discussed and compared with those published in the literature. Next, a retrospective analysis details the strengths and limitations of the experience, and reports on the side effects and additional benefits. Finally, the lessons learned are reported and recommendations made for the successful implementation of a teledermatology system.

2. Methods: design and evaluation methodology

A design and evaluation methodology was followed with the aim of addressing the 4 relevant factors described in the introduction. We conducted a simple process to identify these factors. During a period of 2 months a state of the art review was performed. For each remarkable teledermatology experience, main factors were identified by answering two simple questions: 1) which features contributed to the success of the teledermatology experience? 2) which did not? Additionally, environmental conditions were also analyzed and evaluated in order to establish whether or not certain specific features could affect conditions in the clinic (e.g. if GPs took the photographs or if experts were involved).

Technical factors incorporating system development and image quality requirements were considered first for the study. Eight months were devoted to this stage. The clinical concordance study was conducted over two years, with more active periods irregularly distributed during this period. During the evaluation period, the data needed for image quality evaluation and the impact study were also collected.

2.1 Teledermatology software system

A web application was developed to give support to the teledermatology system. This application was located in a web server placed in a control centre. Thus, GPs and dermatologists could access the system using a standard web browser. The developed system was integrated in a secure environment where confidentiality, privacy and integrity of the exchanged medical data were always guaranteed. The main research question governing the teledermatology system development was: how should the software be designed so that it can be easily used by clinical personnel and support teledermatology consultations? This requirement implied an interactive process with physicians (both GPs and dermatologists) being involved in the design from the outset.

Hence, the software development was planned as a collaborative process between engineers (who developed the system) and physicians (who tested the system). During 4 months, a small group of 4 physicians (1 dermatologist and 3 GPs) took part in the software validation, and a total of 17 teledermatology consultations were performed. Throughout this period, periodic meetings were planned where dermatologists and GPs pointed out weaknesses and usability issues of the system. The software system was improved in the light of these comments. In this way, all the necessary conditions in the clinical setting for the teledermatology process were identified through real practice. The dermatologist and GPs completed a technical questionnaire about the final design of the teledermatology system and their general expectations concerning its use.

2.2 Clinical Image: quality and tools

Image quality greatly influences dermatologists' confidence in providing a diagnosis and is thus a determining factor in the effectiveness of teledermatology. Conventional digital cameras have been demonstrated to be good enough to achieve high image quality [10, 11]. Hence, a Cannon Isus 75x camera was used in each primary care centre to take photographs. It was chosen because it was relatively easy to operate and satisfied all the minimum requirements detailed in clinical image studies. Nevertheless, GPs do require some minimum training in clinical photograph acquisition. Recommendations on acquiring clinical images based on the American Association of Telemedicine (ATA) guidelines [30] and other experiences reviewed [31] were delivered to GPs in order to enhance the quality of clinical images submitted to the dermatologist. By using low cost resources and involving non-expert photographers in the experience, it was possible to answer the main research question: under these conditions, would the quality of the images acquired be high enough to provide a diagnosis? This point was addressed in the clinical concordance study during the

evaluation phase. Image quality was graded as low, fair or high depending on the response of the dermatologists when asked to scale the possibility of offering a diagnosis with telemedicine. Further, they were asked if higher resolution or overall image quality was required in order to provide a diagnosis.

As images constitute the major source of information for dermatologists when making a teledermatology diagnosis, an image viewer based on Flash [32] technology was developed and inserted in the web application in order to help dermatologists explore images in detail. This includes a set of handy diagnostic tools such as longitudinal and area measurements, especially useful for calculating, for example, the area of psoriasis severity index (PASI) or a Scorad Index. In contrast to other commercial image processing software, the technology was very simple, easy to use and specifically adapted to the dermatological setting. Furthermore, the interoperability of image formats transferred to the system was considered and a JPEG-DICOM (Digital Imaging and Communications in Medicine [33]) –JPEG image converter module was developed and included in the teledermatology system.

2.3 Clinical Concordance Study

In order to determine the reliability of the teledermatology system, the degree of concordance (agreement) in diagnosis between teledermatology and face-to-face consultation was measured. The clinical concordance study addressed one basic research question: under our set conditions, how many consultations achieved concordance? In addition, it enabled two more research questions to be answered. How many times did the dermatologist offer a confident diagnosis and was it concordant? Was it related to the dermatological lesion type or the patient's age? A total of 20 physicians (4 dermatologists and 16 GPs including 11 pediatricians) organized in 3

working groups (associated to 3 medical speciality centres) distributed throughout our regional health-care service area participated in this study.

The clinical concordance study was conducted from April 2008 to July 2010. In primary care centres, patients with dermatological lesions that were clearly diagnosed by general practitioners were not considered for a teledermatology consultation, thus avoiding bias in the concordance analysis. There were no more exclusion criteria for other patients with dermatological diseases; hence no pre-selection was involved (neither pathological nor in terms of demographic conditions) when performing teledermatology consultations.

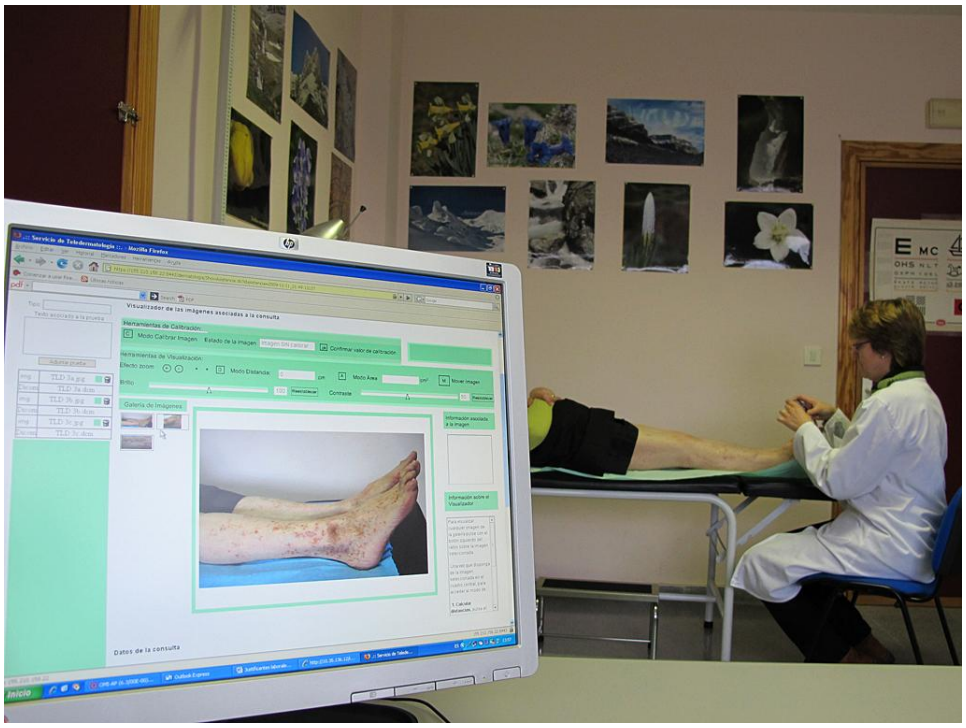


Figure1. Example of a teledermatology consultation

Figure 1 shows an example of the teledermatology procedure in a primary care centre. The PC screen shows the image viewer of the web application where all the clinical images uploaded for each consultation are available for display.

2.3.1 Clinical Concordance study process

The first part of the teledermatology consultation procedure was carried out in a primary care centre. Patients attending the primary care centre with a skin lesion were informed about the teledermatology procedure. If they agreed to participate, they signed the consent form (authorising the sending of their clinical data outside care centres) and the GPs then took photographs of their lesions. Using a standard web browser, the GPs logged into the teledermatology application and filled in the consultation request forms available in the system, attaching clinical images and providing the required text data information. Once finished, it was referred to the associated dermatologist with a request for a diagnosis.

During this phase of the project, dermatologists were requested to issue an initial diagnosis evaluation using teledermatology. After a period of no longer than 1 week, patients were referred to a face-to-face consultation with the same dermatologist to obtain a definitive diagnosis (see Figure 2).

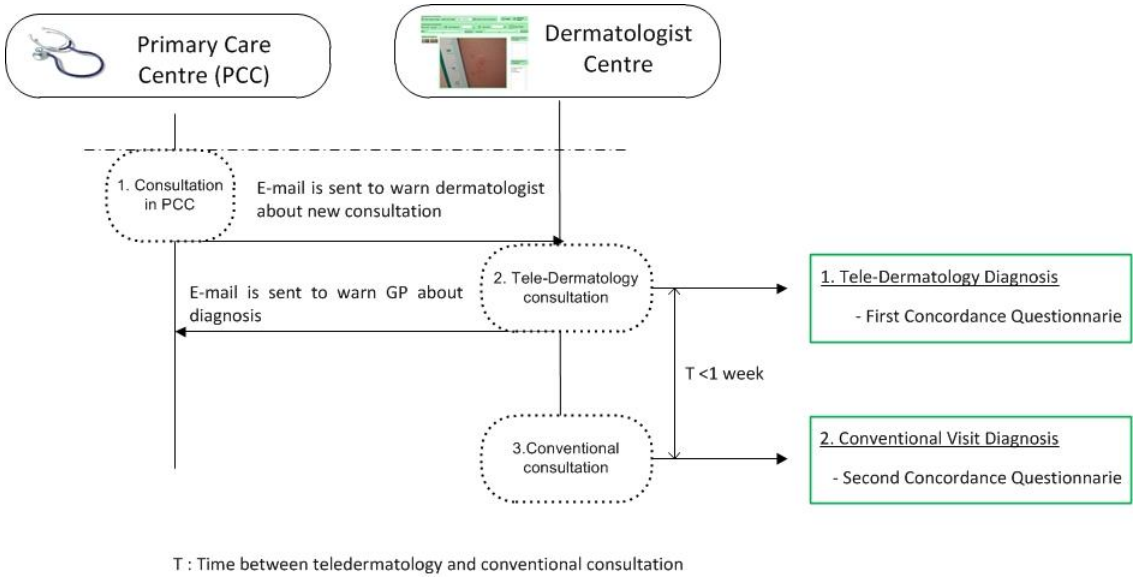


Figure 2. Clinical study procedure

Hence, in this phase, the dermatologists had to complete two questionnaires for each patient, the first after the telemedicine consultation and the second after the conventional visit. The first included questions about the diagnosis opinion, image quality level and quality of information provided by GPs. They were also asked whether they found enough information in the teledermatology system to deliver a confident first diagnosis. They also selected the degree of possibility for offering a diagnosis with telemedicine on a scale ranging from 1 to 5. In the second questionnaire, the dermatologists categorized the concordance level of each pair of consultations as follows: agreement concordance (if both diagnoses provided under the different procedures were the same), partial concordance (if a differential diagnosis was proposed under any one of the procedures) or disagreement concordance (if a mistaken diagnosis was made using teledermatology). They also stated whether they considered it was possible or not to provide a reliable diagnosis with the telemedicine system and the reasons for their opinion.

The GPs also completed a simple questionnaire for each consultation involving teledermatology in order to analyse their general clinical competence in dermatological diagnosis. Hence, they had to give their preliminary diagnosis before submitting referrals. Using the same classification of levels of concordance (agreement, partial and disagreement) as in the previous study, the dermatologists provided their level of concordance with the GPs.

2.4 Impact on health system organization study

Impact on the health system was mainly measured in terms of personnel satisfaction and time impact on clinical routine. Two research questions were formulated regarding the impact on health system organization: 1) how much time did it take to perform a

teledermatology consultation both in primary and specialist care centres? 2) what was the opinion of clinical personnel about the teledermatology usage?

During the concordance evaluation, the impact on time dedicated to teledermatology in clinical practice was also studied. To this end, questions about the time invested were included in the concordance tests.

Periodic meetings were held and email contact was maintained in order to immediately solve problems as they arose so that physicians could avoid stress and not lose interest in using the system. Moreover, a total of 10 physicians completed an opinion questionnaire of 10 questions about the acceptability of the system.

3. Results of the evaluation

The reported results correspond to the requirements and evaluation studies described above. Intensive data collection was carried out using questionnaires and descriptive statistics were used to report the results. It should be noted that evaluation literature and questionnaire design techniques were reviewed before our evaluation study was conducted [34].

3.1 Technical architecture results

At the end of the technical development and evaluation phase, all the technical resources needed for dermatologist consultations were included in the web system. Patients' registration files included patient demographics (gender, date of birth, address, etc), dermatological history (both personal and family), known allergies, drugs, referring dermatologist and correspondent general practitioner. Then, specific consultation request files were designed which comprised the patient identification code, date, sanitary centre and descriptive information about the skin lesion and also the presumptive diagnosis. Furthermore, a codified diagnostic CIE-9 searcher,

modifications for specific clinical vocabulary and verification steps images were included after the evaluation by clinical personnel.

All the physicians completed the technical questionnaires and reported that the system was easy to use, intuitive, and well-adjusted to a clinical setting. They also reported that they had invested an average of 2 hours to properly learn how to use the software. The main drawback was the software was not integrated with patients' EHR (electronic health record). It should be noted that our system was not integrated with the patients' EHR because a common EHR between primary and specialist care has not yet been implemented in health centres in Aragón. Nevertheless, as a specific section for containing patient data was included in the teledermatology system, it was not initially considered as a shortcoming since the required information was available in the system.

3.2 Image quality results

In our experience, image quality was determined as poor in 24% of the total consultations performed. In these cases it was not possible for the dermatologist to issue a diagnosis. Moreover, in 66% (28/43) of the cases where the dermatologist could not offer a diagnosis, this was due to poor quality images.

Dermatologist feedback was very useful for improving image quality. In fact, for 17% of the first 60 consultations performed, the dermatologist reported very low quality images while this percentage declined to 10% for the last 60 consultations. Furthermore, for 35% of the first 60 consultations, the dermatologist reported that the image quality should be improved while the percentage dropped to 17% for the last 60 consultations. Nevertheless, the dermatologists continued to state that image quality should be improved. They also reported that there were significant differences regarding physicians' photography skills and we determined that in addition to the guidelines provided, some physicians would require a specific training course.

3.3 Clinical concordance study results

3.3.1 Patient Demographics

A total of 120 complete concordance consultations were included in the study. 82 of them were pediatric and 38 corresponded to adults. The age range of pediatric consultations was from 3 months to 14 years (mean age 7.0 ± 4.0 years (SD)) and the age range of adults ranged from 15 years to 83 (mean age 56.2 ±17.4 years (SD)). Male (n=61, 53.0% in paediatrics and 47.0% in adults) and female (n=59, 47.0% in pediatrics and 53.0% in adults) participation was equally represented in the evaluated consultations.

3.3.2 Diagnosis Consultations

Table I summarizes all diagnoses provided during the clinical evaluation process in the conventional visits. A total of 116 diagnoses were classified into 4 different groups of diseases (inflammatory dermatoses, infections and infestations, tumors and others) and 4 were diagnosed as normal skin. Both in adult and in pediatric consultations, inflammatory dermatoses were the most commonly referred pathologies (n=49). Tumors (n=24, especially benign ones n=20), and infections and infestations (n=22) were also very common. The rest of the diagnoses were included in the "Other dermatoses" group (n=21). Due to their variability within this group, no individual pathology concordance analysis was done.

Diagnosis Results	**Paediatrics**	**Adult Age**	**Total**
1. **Inflammatory dermatoses**	**33**	**16**	**49**
i) Papulosquamous and eczematous dermatoses	33	10	43
ii) Hives, rashes and purple	0	4	4

iii) Vesicular bullous diseases	0	2	2
2. **Infections and Infestations**	**16**	**6**	**22**
3**. Tumors**	**14**	**10**	**24**
i) Benign	14	6	20
ii) Malign	0	4	4
4. Other Dermatoses	**14**	**7**	**21**
i) Genodermatoses	2	0	2
ii) Hair, nails and mucosal disease	2	0	2
iii) Vascular disorder	4	1	5
iv) Diseases by external agents	1	0	1
v) Skin pigmentation disorder	0	1	1
vi) Adnexal diseases	4	1	5
vii) Rheumatologic diseases	0	2	2
viii) Degeneration diseases	1	1	2
ix) Sub-cutaneous disorders	0	1	1

Table I: Total number of diagnosis consultations

3.3.3 Concordance Diagnosis Results

Table II reports diagnosis concordance results classified in 4 levels (C1: no diagnosis made with telemedicine, C2: discordant agreement, C3: partial agreement and C4: total agreement).

Diagnosis Results	**Age**	**Total**	**C1(%)**	**C2(%)**	**C3(%)**	**C4(%)**
Inflammatory dermatoses	Pediatrics	33	0.00%	6%	18%	76%

	Adult	16	0.00%	13%	25%	62%
Infections and Infestations	Pediatrics	16	13%	6%	6%	75%
	Adult	6	0.00%	0.00%	17%	83%
Tumors	Pediatrics	14	0.00%	14%	7%	79%
	Adult	10	0.00%	0.00%	20%	80%
Other dermatoses	Pediatrics	14	15%	15%	15%	55%
	Adult	7	0.00%	0.00%	0.00%	100%

Table II: Concordance Diagnosis Results (C1: no diagnosis made with telemedicine, C2: discordant agreement, C3: partial agreement and C4: total agreement)

High concordance rates were found in pediatrics for inflammatory dermatoses, infections and infestations and also tumors. Lower rates of total agreement were found for others pathologies and also some discordant diagnosis (C2). Nevertheless, within this group, total agreement (C4) was found for genodermatoses (2/2) and vascular disorders (3/4).

High concordance rates were found in the adult age group for infections and infestations and tumors. High concordance was also found in the "other dermatoses" group but 6 consultations were not enough to obtain significant conclusions. Note that the total agreement (C4) for inflammatory dermatoses was not so high and also that some mismatched diagnoses were delivered (2/16).

3.3.4 Teledermatology Effectiveness

Table III reports some indicators that reflect dermatologist confidence and caution in issuing a diagnosis, and the general effectiveness of teledermatology (as a filter tool and to give patient priority). Also, treatment management results are reported for

mismatched diagnoses. It should be noted that dermatologists were able to offer more than one reason when a first reliable diagnosis could not be issued.

Indicator	Value(%)(cases/total)
Dermatologist issues first reliable diagnosis	64% (77/120)
- Dermatologist would recommend a second conventional visit to confirm diagnosis.	35% (27/77)
Dermatologist would not issue first reliable diagnosis	36% (43/120)
- Reasons:	
→Poor quality image	66% (28/43)
→More images required	12% (5/43)
→Not enough information provided by GPs	56% (24/43)
→Additional clinical tests required (e.g blood analysis, histological studies or use of dermatoscopic images)	12% (5/43)
Teledermatology Effectiveness	
- As a filter tool: first reliable diagnosis + no second visit	42% (50/120)
→Concordance (high grade of success)	90% (45/50)
→Discordant diagnosis	10% (5/50)
→Same treatment	(2/5)
→Different treatment	(3/5)
- To give priority to conventional consultations	3% (4/120)

Table III: Teledermatology Effectiveness Results

As is shown in Table III, it is very interesting to note that from a total of 120 consultations, in 50 cases the dermatologist provided a confident diagnosis using teledermatology and did not recommend a second conventional visit to confirm the diagnosis. This means that teledermatology usage for avoiding dermatological referrals

was rated at 42% with 90% effectiveness, given that 45 cases were correctly diagnosed and concordance was total. It should also be remarked that in 4 cases, dermatologists reported that although it was not possible to diagnose through teledermatology, the system had been used to give priority to conventional consultation. Noteworthy issues arising from Table III are discussed in the discussion section below.

3.3.5 Concordance Results in primary care

Additionally we conducted a diagnostic concordance study between GPs and dermatologists. Not all GPs completed concordance questionnaires and a total of 69 consultations were analysed.

The GPs did not provide a diagnosis in 14% of consultations, they made a wrong diagnosis in 27%, obtained a partial concordance in 14% and total agreement in 43%. Although inflammatory dermatoses and infections were the most frequent diagnoses referred, there was a medium-high degree of agreement between dermatologists and GPs for those cases (55% and 62% respectively).

3.4 Impact Study Results

3.4.1 Impact on Time Study

Teledermatology consultations are faster than conventional consultations for dermatologists (see table IV), thus teledermatology could be effective for speeding up normal consultations and reducing waiting queues. On the other hand, GPs invest much time during the consultation in taking images and then uploading them to the teledermatology system. It was clear that total time invested in primary care centres should be reduced.

item	Average Time (min)
Time invested by dermatologist in a consultation with teledermatology	6
Time invested by dermatologist in a face to face consultation	10
Time spent by GPs to take clinical images	12.3
Time spent by GPs completing online information about referral (patient and disease information) and attaching clinical image.	6.7
Total time spent by GP in a consultation with teledermatology consultation	19
Time invested by a GP in a normal dermatology consultation	10

Table IV: Time Impact Study

3.4.2 Impact on Physicians Study

Table V summarizes the results of the physician (dermatologists and GPs) opinion questionnaires.

Question	Yes	No	Doubts
Was there any organizational change due to teledermatology introduction?	4/10	6/10	0/10
Is the system really useful to solve the problems for which it was designed?	9/10	0/10	1/10
Is it effective for urgent situations?	9/10	1/10	0/10
Are you worried about patients' data confidentiality because of its transmission through the internet?	3/10	7/10	0/10
Would you recommend its use for daily consultations?	9/10	0/10	1/10

Table V: Physician's opinion results

100% of physicians declared themselves to be satisfied or very satisfied with the use of the teledermatology system and considered its utility to be very satisfactory for urgent situations. They also remarked that it was a valuable tool to provide dermatological care to patients with mobility problems (because of distance or physical handicaps), to confirm diagnosis doubts, for GPs to improve their dermatological knowledge, to provide a fast diagnosis when required, to improve patients' opinions about the health system, to follow-up a patient who can be monitored by the GP and also to avoid unnecessary patient transfers, especially avoiding cosmetic surgery consultation referrals.

Nevertheless, 60% of GPs reported that some difficulties were found in teleconsultations. Problems that arose included the following: (1) teleconsultations could not be performed due to deficiencies in health centre facilities (e.g. limited internet access), (2) children moving too much and not keeping still, (3) some parents were concerned about sending images through Internet, especially in cases of language problems with foreign patients, (4) extra-time was required in order to send images and this delayed conventional consultations (5) frequently they had to perform teleconsultations from their homes due to technical troubles and limited time for consultations (6) the limited number of patients that could be scheduled per week in dermatology centres delayed the reliability study. They also pointed out that it would be very positive if the teledermatology system was integrated into clinical health records.

4. Discussion of the evaluation and related work

Although image quality improved during the experience and good rates of agreement were found in the clinical concordance study, the results showed that GPs still need to improve their level of clinical image acquisition. In fact, low image quality was given as

the reason for the inability of the dermatologist to provide a diagnosis in 66% of the undiagnosed teleconsultations.

Nevertheless, as stated above, high rates of agreement were found in our concordance studies for both pediatric and adult diseases. We examined separately and in detail diseases for pediatrics and adults because the pathologies manifested in the age groups are not the same. Furthermore, age could influence certain issues in the teleconsultation performance. During this period, no selection of pathologies was made and a wide range of dermatology conditions were referred to the teledermatology service.

A wide range of concordance rates from 54% to 89% have been reported in the literature [7,11,25,35]. It should be noted that the conditions were not the same in all cases and the skin lesions studied were not the same. In order to compare our results, studies with similar conditions were selected. For instance, in [11], where low-cost resources were also used, concordance ranged in general between 81%-89%, specifically 100% for infestations and 77-100% for inflammatory dermatoses (depending on the teledermatologist). Nevertheless, photographs were not acquired by GPs in the clinic scenario and no specific inclusion or exclusion criteria were applied, so high image quality and lesions that could be clearly indicated by GPs could have had an influence on these high rates.

Lower concordance values than ours for diagnosis with teledermatology for adults have been reported in [7] (54% of total agreement), where the conditions of the study corresponded, like ours, to everyday general practice.

In the present study, high rates of concordance were found for genodermatoses (total agreement: 100%) and vascular disorders (total agreement: 75%). Although these results have limited significance due to the few consultations performed, similar outcomes have been reported in the literature [7] where 67% of concordance has been

determined for vascular diseases**.** Nevertheless, few cases of these pathologies have been reported in other studies, and specific analysis with more patients would be required to extract general results regarding concordance for these particular dermatoses.

It should be noted that more pediatricians were included in our study because few studies of teledermatology experiences focused on children's skin conditions have been reported to date [12,20,36]. The fact that our study is one of the first [12] to provide a specific concordance analysis for pediatrics carried out, moreover, under non ideal conditions and for general dermatological clinics represents one of its strong points. We obtained high rates of concordance for inflammatory dermatoses (75.75%) (which was also the most common referral diagnosis), thus presenting similar outcomes to other studies such as [12] where 82% was achieved for pediatric rashes. Given this high concordance, the teledermatology system could be useful for filtering referrals of inflammatory dermatoses (being diagnosed by teledermatology). Compared with adult concordance analysis, we determined that in pediatrics the total agreement rate for inflammatory dermatoses was considerably higher (76% against 62 %). Nevertheless, this difference was the opposite for "other dermatoses" groups where 100% rate was detected in adults as against 54% for pediatrics. This indicates that in pediatric dermatology, the specific and most common referrals are easily identified with teledermatology. Regarding concordance rates in the "other dermatoses" group, no general conclusions can be drawn due to the low number of consultations performed. Nevertheless, our results suggest that uncommon diseases in children are more difficult to detect with teledermatology than in adults.

This study suggests that GPs have few deficiencies in dermatological diagnostic skills, thus teledermatology could be used effectively for diagnostic confirmation. The

agreement rate between GPs and dermatologists was medium (43%), similar to [20] where 48% of total concordance was reported for paediatricians and dermatologists. We also determined that, for inflammatory dermatoses and infection cases, concordance agreement rates were relatively high, thus teledermatology could be very useful for diagnosis confirmation in these cases, avoiding patient transfers.

As was shown in the results, an additional 10 min were required in primary care centres to perform the teledermatology consultations. There are not many reports about the additional time required for teledermatology. In [8] it was reported that 7 minutes were required in primary care centres to perform a teledermatology consultation (4 minutes for image acquisition and 3 minutes for sending information to the dermatologist). These results differ from our results. This is mainly due to the fact that in pediatrics, the image acquisition process is not as easy as with adults because children tend to have difficulties in keeping still. In addition, in our case a specific web application was used for teledermatology and not e-mail as in the previous work [8]. This led to an increase in the time required to introduce all the data for patient registration and consultation in the system. Similar outcomes for time requirements were found in [9], were 11.5 minutes were calculated for a teledermatology consultation in primary care centres. The main advantage of the system is that all information is electronically available. However, our system was not integrated with the patients' electronic health records. As was also reported in [9], its implementation would certainly reduce the time invested by GPs for teledermatology consultations.

Physicians involved in this project declared themselves to be very satisfied with the use of teledermatology and 90% of them would recommend including teledermatology in clinical routine. It is interesting to note that despite this positive view, the number of consultations where dermatologists considered they could perform a diagnosis without a

second conventional visit (50/120) was lower than the number with total agreement rates (86/120). The cautious approach of physicians thus set a limitation on the use of teledermatology, and its usage for filtering referrals was rated at 42%. From previous consultations, five diagnosis errors were detected, representing 4% of the total, and 45 were totally in agreement. This supports the use of teledermatology for filtering referrals. Additionally, it is interesting to remark that in 4 cases the teledermatology system was used to give priority for a conventional consultation.

Regarding patient satisfaction, an impact study was not completed since this was due to be carried out after the permanent establishment of the teledermatology system. This phase was not reached in our experience.

5. Retrospective analysis

The teledermatology system was tested in our region over a period of three years. Although the four relevant factors identified as being essential to the development and evaluation of the system were successfully handled and the system was both technically and clinically viable, some problems did eventually emerge and limitations were identified which required solutions before the HCO would consider the long-term set-up of the teledermatology system. HCO approval was not finally obtained. After the three-year experience, a retrospective analysis of the results of the evaluation studies and the project as a whole was performed with the aim of answering the following question: what significant factors emerged during the implementation of the teledermatology service and how did they affect the use and adoption of the system. In order to answer this question, interviews were planned during and after the experience with a small group of the GPs and dermatologists involved in order to discuss not only the main strengths and limitations but also the environmental circumstances and side effects that emerged throughout the experience and conditioned its set-up. We present here a two-

fold retrospective analysis. The first part discusses the strengths and limitations of the telemedicine system as revealed by the evaluation study results. The second part discusses additional benefits and side effects identified after the three-year experience as being significant in the implementation of the system.

5.1 Strengths of the system

The main strengths of the teledermatology setup were found in the multidisciplinary collaboration, the clinical concordance study and the degree of physicians' satisfaction.

Clinical and technical personnel working together with a common agenda was essential to our teledermatology experience. This cooperation led to the development of a teledermatology environment adapted to the clinical setting. There is no doubt that the fact that the teleconsultation procedure was so easy contributed to encouraging physicians' participation. This approach is in line with other reported studies on telemedicine systems emphasising that successful implementation is a final outcome of a dynamic process where the interaction among all factors (clinical, social, technical and organizational) must be assessed in order to optimize the system [37,38].

The high rates of agreement in both the pediatric and adult concordance studies, which compared well with those reported in the published literature, was considered strength of the teledermatology system. Furthermore, the results showed that when the dermatologist emitted a reliable diagnosis, the total agreement rate was 90%. Hence, these concordance study results demonstrated that the teledermatology system was good enough to provide the same diagnosis as in a traditional consultation (both in terms of different skin diseases and dermatologist reliability).

The physicians' satisfaction and interest in teledermatology were also important strengths that supported its adoption and long-term set-up. In addition, the physicians involved described several other possible applications of teledermatology apart from its

diagnosis function (filter referrals, discarding urgencies, etc). As is widely known, acceptability on the part of clinical personnel substantially affects the success of telemedicine systems.

5.2 Limitations of the system

The principal limitations revealed in the teledermatology experience were the time involved and the lack of EHR integration. Time-scheduling constituted an important limitation as extra time was required to perform teleconsultations in primary care centres (nearly 20 min per patient). Daily routine consultations should not be delayed by the use of telemedicine and the same rate of consultations must be maintained. However, GPs were required to invest additional time. Furthermore, physicians reported that most of the additional time was taken up with registering patients in the teledermatology system. This limitation is undoubtedly a consequence of the lack of integration with EHR.

5.3 Side effects and additional benefits

Various problems emerged during the evaluation that delayed the study. However, enough information was collected in order to be able to assess the concordance level achieved for all the skin lesions studied. After spending two years on the concordance study, physicians appeared to lose interest in the teledermatology system and at the end of the two-year period they seldom sent teledermatology consultations. At the end of the experience and during the concordance study, they were asked why the usage of the system had eventually decreased. The extra time involved and difficulties in performing consultations in health centres were the main reasons given. Some technical limitations such as inadequate health centre facilities and internet connections caused difficulties in some teleconsultations. This meant that GPs and dermatologists frequently had to perform teleconsultations from their homes and consequently invest extra time and

work to perform the consultations. This extra workload would normally involve some additional remuneration for GPs for dealing with telemedicine consultations. Similarly, dermatologists would expect to be paid for teleconsultations added to their normal schedule. Furthermore, organizational changes would be required to include teledermatology in the clinical routine. This was a limitation in our experience, in which all physicians were volunteers. The need for additional payment to physicians was also reported in [2] where, as in our study, a list of facts of daily routine consultations were detected to condition teledermatology failure or success. Nevertheless, the main limitation in our project was the HCO involvement since the outset of the project due to presented side effects could have been solved. Indeed, GPs and dermatologists continued to stress their interest in teledermatology at the end of the experience but they reported that the limitations identified should be addressed.

The overall view of the experience was very positive and apart from side effects, additional benefits were also identified in the teledermatology experience. For example, GPs skills could be improved through the use of teledermatology since they can receive the dermatologist's feedback that directly relates to the skin disease images. Eventually, the system will provide a repository of dermatological images linked to standard diagnoses that, similar to a dermatological atlas, could be very useful for learning. Besides, the efficacy and viability of teledermatology for medical training and educational benefits in treatment plans has already been demonstrated in other studies [8, 39]. Furthermore, thanks to teledermatology systems, tracking dermatology referrals from primary health centres with dermatologist support is possible, avoiding patients having to travel to specialist centres for routine reviews. In addition, communication between physicians is improved.

6. Conclusion: Lessons Learned

This section presents the main lessons learned both from the evaluation studies and the teledermatology project as a whole. Specifically, lessons learned from the project are discussed from the point of view of alignment theories. As a result, several key recommendations for future practice are made which will be valuable for other similar experiences.

6.1 Lessons learned from the evaluation study

The clinical concordance study was essential for determining the reliability of the system. The results showed that high rates of accuracy can be obtained with teledermatology both for adults and pediatrics with affordable technical requirements. Furthermore, high rates of agreement were found for most common dermatologic lesion referrals (inflammatory dermatoses) and it was demonstrated that if the dermatologist emitted a reliable diagnosis, total concordance was achieved in nearly 100% of the cases (without significant treatment differences for the wrong ones). In addition, it was concluded that GPs had good dermatologic skills. Therefore, with the support of dermatologist feedback the system could be used for filtering dermatological referrals. It is interesting to note that dynamic collaboration between technical and clinical personnel was a positive factor leading to improvements in the teledermatology experience.

Nevertheless, the results showed that the time invested in teleconsultation in primary care centres was as an important limitation. We concluded that the lack of EHR integration was the main reason for the time problem and consequently such integration was deemed necessary for the long term implementation of the system.

6.2 Lessons learned from the project

Alignment of information technology systems with organizational and business strategies in hospitals has been identified as a critical key factor in the successful implementation (long-term set-up) of a telemedicine system [27,28]. Our study provides a formal evaluation of the introduction of a teledermatology system that could be very helpful for investment decisions by HCO managers in relation to teledermatology. This study recommends the use of teledermatology as a complementary tool in daily consultations at primary care centres and as an effective means to filter dermatology referrals (reducing the need for patient transfers for live-consultations). It could also be useful for prioritizing patients requiring urgent attention.

Nevertheless, health-centre facilities, EHR integration, physician schedules, workloads and remuneration were important limitations in our experience and were thus identified as key points requiring careful consideration in the setup of teledermatology systems.

As suggested in [37], good telemedicine implementations are developed after a process where the dynamic interaction among a combination of socio-technical factors is optimized. It is clear that the limitations identified in the present study should have been addressed during the evaluation study. However, these limitations could not be tackled because HCO managers were not involved in the evaluation study. In retrospect, it would have been not only desirable but also highly recommendable for the HCO to have been involved from the outset (Step 1, 2 and 3). The initiative in this case was taken by medical personnel, and the HCO was not involved until the final stage of Step 3. The main lesson learned was the erroneous assumption that this lack of interaction with the HCO (which had to approve the final implementation of the teledermatology system) was not going to affect the evaluation study of the system. Eventually, this lack of HCO involvement caused delays and difficulties during the setup and prevented the

system from being evaluated from the patients' point of view in the final stage of Step 3 of the study. Furthermore, the lack of resources and the loss of interest in the teledermatology usage caused by the extra workload eventually turned out to be obstacles impossible to overcome. These could have been avoided if the HCO had been involved in the evaluation of the project.

While the system was not finally implemented in our region, the teledermatology experience proved to be very positive. It is clear that the long-term implementation of a teledermatology system and the funding required is a big issue that greatly depends on the HCO.

References

[1] Kaddu S, Soyer HP, Gabler G, Kovarik C. The Africa Teledermatology Project: Preliminary experience with a sub-Saharan teledermatology and e-learning program. J Am Acad Dermatol 2009;61:155-7.

[2] Oakley A, Rademaker M, Duf.ll M. Teledermatology in the Waikato region of New Zealand. J Telemed Telecare. 2001;7 Suppl 2:59-61. PMID: 11747661

[3] Whited J.D, Teledermatology research review. Int J Dermatol 2006, 45: 220-229. PMID:16533219.

[4] Bergmo TS. A cost-minimization analysis of a realtime teledermatology service in northern Norway. J Telemed Telecare. 2000;6(5):273-7. PMID: 11070588

[5] Lamminen H, Tuomi M-L, Lamminen J, Uusitalo H. A feasibility study of realtime teledermatology in Finland. J Telemed Telecare. 2000;6(2):102-7. PMID: 10824378

[6] Moreno-Ramirez D, Ferrandiz L, Perez Bernal A, Carrasco R, Duran, Rios Ma JJ, Camacho F. Teledermatology as a filtering system in pigmented lesion clinics. J Telemed Telecare. 2005;11(6):298-303. PMID: 16168166

[7] Du Molin MF, Bullens-Goessens YI, Henquet CJ, Brunenberg DE, de Brun-Geraerds DP, Winkens RA, Dirksen CD, Vierhout WP, Neumann HA. The reliability of diagnosis using store-and-forward teledermatology. J Telemed Telecare. 2003;9(5):249-52. PMID: 14599326

[8] Van den Akker. Th W, Reker C H M, Knol A, Post J, Wilbrink J, Van der Veen J P W. Teledermatology as a tool for communication between general practitioners and dermatologists. J Telemed Telecare. 2001;7(4):193-8. PMID: 11506753

[9] Berghouta R. M, Eminovíc N, De Keizera N. F, Birnieb E. Evaluation of general practitioner's time investment during a store-and-forward teledermatology consultation.

Internationa. Int J Med Inform. 2007 Dec;76 Suppl 3:S384-91. Epub 2007 May 25. PMID: 17532256

[10] Hockey A D, Wootton R, Casey T. Trial of low-cost teledermatology in primary care. J Telemed Telecare. 2004;10 Suppl 1:44-7. PMID: 15603607

[11] High WA, Houston MS, Calobrini SD, Drage LA, McEvoy MT. Assessment of the accuracy of low-cost store and forward teledermatology consultation. J Am Acad Dermatol. 2000 May;42(5 Pt 1):776-83. PMID: 10775853

[12] Heffner VA, Lyon VB, Brousseau DC, Holland KE, Yen K. Store-and-forward teledermatology versus in-person visits: a comparison in pediatric teledermatology clinic. J Am Acad Dermatol. 2009 Jun;60(6):956-61. Epub 2009 Apr 11. PMID: 19362751

[13] Jutra A. Teleroentgendiagnosis by means of videotape recording. American Journal of Roentgenology 1959;82:1099–102

[14] Murphy RL, Bird KT. Telediagnosis: a new community health resource. Observations on the feasibility of telediagnosis based on 1000 patient transactions. Am J Public Health. 1974;64:113–19.PMID:4129472

[15] Char A, Kalyanpur A, Puttanna Gowda VN, Bharathi A, Singh J. Teleradiology in an inaccessible area of northern India. J Telemed Telecare. 2010;16 (3):110-3. PMID: 20386032

[16] Caffery L, Manthey K. Implementation of a web-based teleradiology management system. J Telemed Telecare, 2004; 10(Suppl 1):22–25. PMID:15603599

[17] Luccichenti, G, Ngo Dinh N, Cademartiri, F, Evangelisti, G, Paolillo, A, Bastianello, S. Teleradiology system accessible through a common web browser. Radiol Med, 2004; 108(5-6), 542-548. PMID:15723000

[18] Van de Wetering R, Batenburg R. A PACS maturity model: A systematic meta-analytic review on maturation and evolvability of PACS in the hospital enterprise. Int J Med Informatics 2009; 78(2): 127-140. PMID:18752988

[19] Szot A, Jacobson FL, Munn S, et al. Diagnostic accuracy of chest X-rays acquired using a digital camera for low-cost teleradiology. Int J Med Informatics 2004;73:65–73. PMID:15036080

[20] Chen T. S, Goldyne M. E, Mathes E. F. D, Frieden I. J, Gilliam A. E. Pediatric teledermatology: Observations based on 429 consults. J Am Acad Dermatol 2010; 62:61-6). PMID: 19926163

[21] Weinstock M. A, Nguyen F. Q, Risica P. M. Patient and referring provider satisfaction with teledermatology. J Am Acad Dermatol . 2002 Jul;47(1):68-72. PMID: 12077584

[22] Williams TL, Esmail A, May CR, Griffiths CE, Shaw NT, Fitzgerald D, Stewart E, Mould M, Morgan M, Pickup L, Kelly S. Patient satisfaction with teledermatology is related to perceived quality of life. Br J Dermatol. 2001 Dec;145(6):911-7. PMID: 11899144

[23] Armstrong AW, Sanders C, Farbstein AD, Wu GZ, Lin SW, Liu FT, Nesbitt TS. Evaluation and Comparison of Store-and-Forward Teledermatology Applications. Telemed J E Health 2010. May;16(4):424-38. PMID: 20438384

[24] Van der Heijden JP, Spuls PI, Voorbraak FP, de Keizer NF, Witkamp L, Bos JD. Tertiary Teledermatology: A Systematic Review. Telemed J E Health. 2010 Jan-Feb;16(1):56-62. PMID: 20064068

[25] Warshaw E. M et al. Accuracy of teledermatology for pigmented neoplasms. J Am Acad Dermatol. 2009 Nov;61(5):753-65. Epub 2009 Aug 12. PMID: 19679375

[26] Warshaw EM, Hillman YJ, Greer NL, Hagel EM, Macdonald R, Rutks IR, Wilt TJ. Teledermatology for diagnosis and management of skin conditions: A systematic review. J Am Acad Dermatol. 2010 Oct 29. PMID: 21036419

[27] Luftman J, Assessing Business-IT alignment Maturity. Communications of the Association for the Information Systems (AIS), 2000; 4(14):1–49

[28] Van de Wetering R, Batenburg R, Versendaal J, Lederman R, Firth L. A balanced evaluation perspective: picture archiving and communication system impacts on hospital workflow, J Digit Imaging, 2006; 19 (Suppl. 1):10-17 PMID:16763932

[29] Bush M, Lederer A.L, Li X, Palmisano J, Rao S. The alignment of information systems with organizational objectives and strategies in health care. Int J Med Inform, 2009; 78 (7):446–456. PMID:19307148

[30] American Telemedicine Association. Practice guidelines for teledermatology December 2007.

[31] Jakowenko J. Clinical Photography. J Telemed Telecare .2009; 15: 7–22

[32] Flash technology. URL:http://www.adobe.com/es/products/flashplayer/. Accessed: 2011-03-18. (Archived by WebCite® at http://www.webcitation.org/5xHSi4KrS).

[33] Digital Imaging & Communications in Medicine (DICOM). URL: http://medical.nema.org/. (Archived by WebCite® at [http://www.webcitation.org/5Ey9Q76H3).

[34] Taylor P. Evaluating telemedicine systems and services. J Telemed Telecare 2005; 11: 167–177

[35] Ishioka P, Tenório JM, Lopes PR, Yamada S, Michalany NS, Amaral MB, Pisa IT, Hirata SH, Almeida FA. A comparative study of teledermatoscopy and face-to-face examination of pigmented skin lesions. J Telemed Telecare 2009;15(5):221-5. PMID: 19590026

[36] Fieleke DR, Edison K, Dyer JA. Pediatric Teledermatology. A Survey of Current Use. Pediatr Dermatol. 2008 Mar-Apr; 25(2):158-62. PMID: 18429770

[37] Wears RL, Berg M. Computer technology and clinical work: Still waiting for Godot. JAMA 2005; 293(10):1261-1263

[38] Woods DD. Designs are hypotheses about how artifacts shape cognition and collaboration. Ergonomics,1998;41:168-173.

[39] Shaikh N, Lehmann CU, Kaleida PH, Cohen BA. Efficacy and feasibility of teledermatology for paediatric medical education. J Telemed Telecare. 2008;14(4):204-7. PMID: 18534955

Authors' Contributions

N.L contributed to the development of the system, the design of the evaluation study and the processing of questionnaires, and was thus involved in data analysis and interpretation. She also led the preparation of the first drafts and the final manuscript. A.A led the conception and design of the project. He also contributed to the data analysis and interpretation, and to the preparation of the first drafts and the final version of the manuscript. Y.G is the main dermatologist involved in the project. She contributed throughout the evaluation study performing teledermatology consultations and contributing to the data analysis. She also contributed to the reviewing and revising of the first drafts and final version of the manuscript. R.M is the main GP involved in the experience. She contributed throughout the evaluation study performing teledermatology consultations and contributing to the data analysis. She also contributed to the reviewing and revising of the first drafts and final version of the manuscript. J.G contributed to the design of the evaluation study, and critically revised the data analysis and the first drafts and final version of the manuscript. All the authors approved the final version of the manuscript.

Statement on conflicts of interest

There is no conflict of interest.

***Summary points**

Summary Table

What was already known about the topic
The effectiveness of telemedicine to provide dermatological care by means of store and forward telemedicine systems. This is one of the most popular applications of telemedicine implementations.
High diagnosis accuracy can be achieved with affordable technical requirements.

What this study added to our knowledge
This study reports a detailed concordance analysis for child dermatological clinics and a teledermatology effectiveness study.
The study provides a wealth of practical details regarding the methodology and evaluation performed which serve to enhance the transferability of the results to other teledermatology experiences.
This study takes a different approach by discussing the strengths and limitations of a teledermatology implementation experience in a realistic manner. All the factors that emerged as being significant during the experience and which affected the long-term set-up of the system are discussed. In this way, a new set of key factors and lessons learned are provided for future teledermatology implementations.

Highlights

1. This paper reports a realistic experience in the design and evaluation of a telemedicine solution for remote dermatology consultation (tele-dermatology) in Aragón, Spain.

2. This study takes a different approach discussing the strengths and limitations of a teledermatology experience in a realistic manner.

3. A list of identified keys and lessons learned is provided for future teledermatology implementations.

4. To the best of our knowledge this is one of the few experiences that involve many pediatricians in the experience providing in this way a detailed concordance analysis for children dermatological clinics.

Supplementary Material

Concordance Questionnaire for dermatologist I: Teledermatology consultation

Concordance Questionnaire I: Teledermatology Consultation
General Information 1. Basic Patient information: *Patient code, gender, age, race* 2. Is it a paediatric consultation? *Yes* *No*
Diagnosis 3. Diagnosis with telemedicine system: 4. How could this skin lesion be classified? *- Inflammatory dermatoses* *- Infections and Infestations* *- Tumors* *- Others* *(*Detailed classification is provided in table I)*
Quality of images and information 5. On a scale from 1 to 5, select the degree of possibility of offering a diagnosis with telemedicine: 1. *Impossible* 2. *Conventional visit is required due to poor quality of the images.* 3. *Conventional visit is recommended although image quality is quite fair and it is possible to make a preliminary identification of the disease.* 4. *Image quality is high and it is possible to offer a diagnosis.* 5. *Image quality is high and there is total confidence in the diagnosis provided with telemedicine.*
Diagnosis Reliability 6. Did you find enough information in the teledermatology system to deliver a confident first diagnosis? *Yes* *No*
7. If not, what would you have required? 1. *Higher resolution and overall quality of attached information*

2. *More tests*
3. *Detailed information about the referral*
4. *More information about patient's health record*
5. *More tools for attached data treatment*
6. *Additional information not available in teledermatology system*
7. *Others, please specify*

Time questions

8. How long was the teledermatology consultation?

Concordance Questionnaire for dermatologist II: Conventional consultation

Concordance Questionnaire II: Conventional Consultation

Concordance

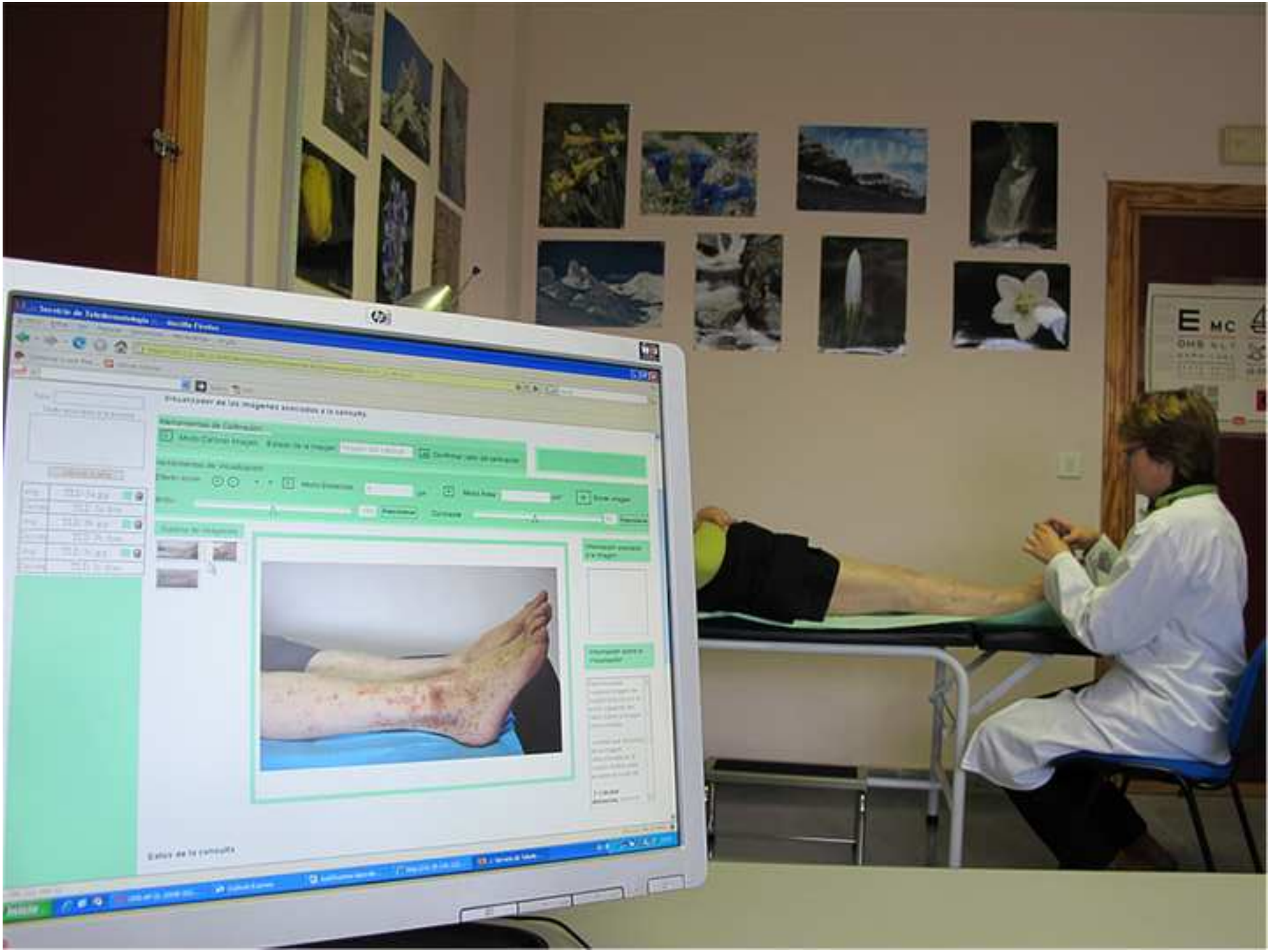
1. Which is the concordance level?

1. *It was not possible to perform a diagnosis with teledermatology.*
2. *Disagreement (if teledermatology diagnosis is mistaken)*
3. *Partial concordance (if a differential diagnosis was also proposed with either of the procedures)*
4. *Agreement (if both diagnoses provided with the different procedures were the same)*

(General Information and diagnosis section are the same as in the previous test)*

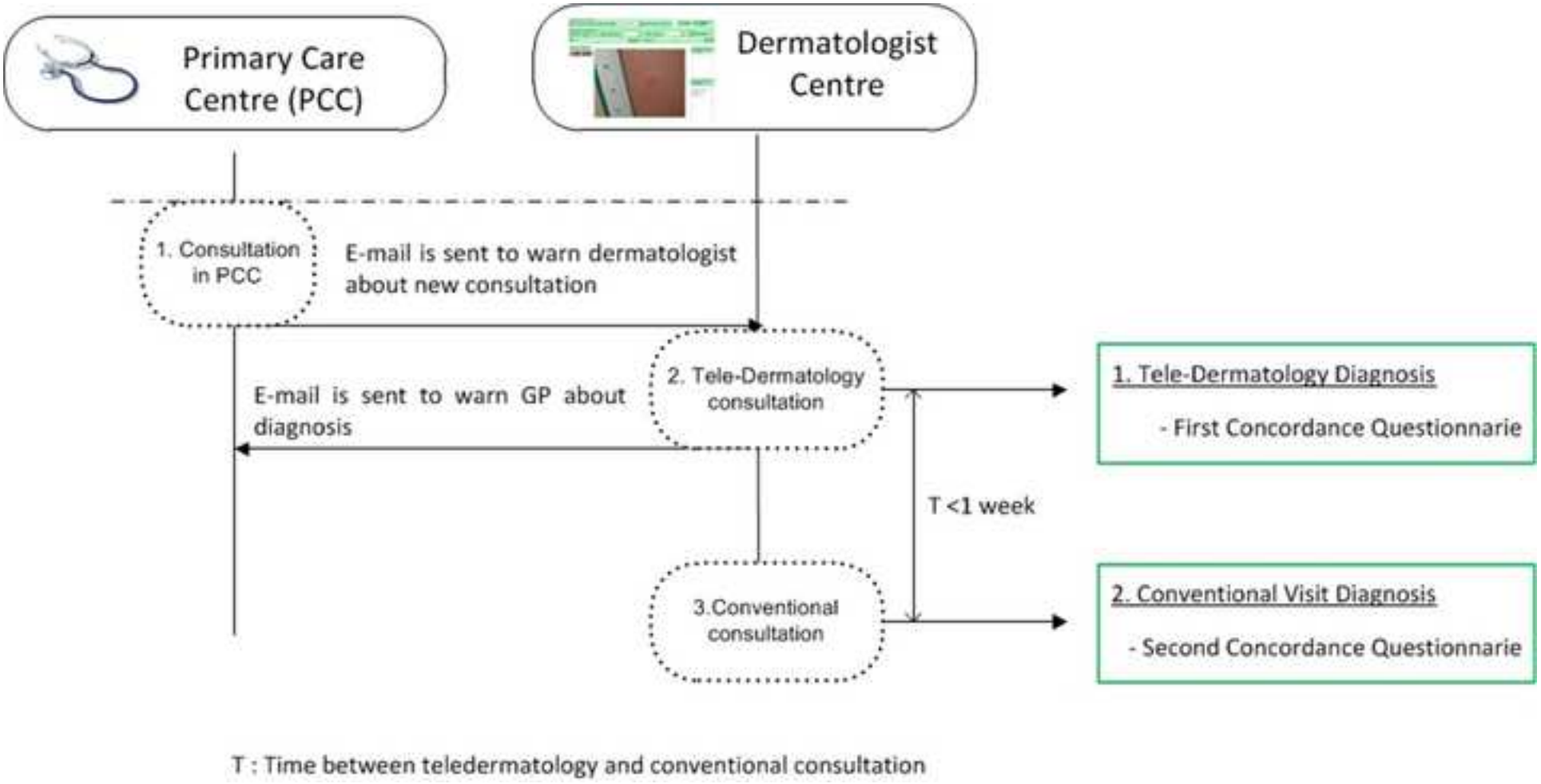
Figure

Click here to download high resolution image



Figure

Click here to download high resolution image



T : Time between teledermatology and conventional consultation

Tables

Diagnosis Results	**Paediatrics**	**Adult Age**	**Total**
1. **Inflammatory dermatoses**	**33**	**16**	**49**
i) Papulosquamous and eczematous dermatoses	33	10	43
ii) Hives, rashes and purple	0	4	4
iii) Vesicular bullous diseases	0	2	2
2. **Infections and Infestations**	**16**	**6**	**22**
3**. Tumors**	**14**	**10**	**24**
i) Benign	14	6	20
ii) Malign	0	4	4
4. Other Dermatoses	**14**	**7**	**21**
i) Genodermatoses	2	0	2
ii) Hair, nails and mucosal disease	2	0	2
iii) Vascular disorder	4	1	5
iv) Diseases by external agents	1	0	1
v) Skin pigmentation disorder	0	1	1
vi) Adnexal diseases	4	1	5
vii) Rheumatologic diseases	0	2	2
viii) Degeneration diseases	1	1	2
ix) Sub-cutaneous disorders	0	1	1

Table I: Total number of diagnosis consultations

Tables

Diagnosis Results	Age	Total	C1(%)	C2(%)	C3(%)	C4(%)
Inflammatory dermatoses	Pediatrics	33	0.00%	6%	18%	76%
	Adult	16	0.00%	13%	25%	62%
Infections and Infestations	Pediatrics	16	13%	6%	6%	75%
	Adult	6	0.00%	0.00%	17%	83%
Tumors	Pediatrics	14	0.00%	14%	7%	79%
	Adult	10	0.00%	0.00%	20%	80%
Other dermatoses	Pediatrics	14	15%	15%	15%	55%
	Adult	7	0.00%	0.00%	0.00%	100%

Table II: Concordance Diagnosis Results (C1: no diagnosis made with telemedicine, C2: discordant agreement, C3: partial agreement and C4: total agreement)

Tables

Indicator	Value(%)(cases/total)
Dermatologist issues first reliable diagnosis	64% (77/120)
- Dermatologist would recommend a second conventional visit to confirm diagnosis.	35% (27/77)
Dermatologist would not issue first reliable diagnosis	36% (43/120)
- Reasons:	
→Poor quality image	66% (28/43)
→More images required	12% (5/43)
→Not enough information provided by GPs	56% (24/43)
→Additional clinical tests required (e.g blood analysis, histological studies or use of dermatoscopic images)	12% (5/43)
Teledermatology Effectiveness	
- As a filter tool: first reliable diagnosis + no second visit	42% (50/120)
→Concordance (high grade of success)	90% (45/50)
→Discordant diagnosis	10% (5/50)
→Same treatment	(2/5)
→Different treatment	(3/5)
- To give priority to conventional consultations	3% (4/120)

Table III: Teledermatology Effectiveness Results

Tables

item	Average Time (min)
Time invested by dermatologist in a consultation with teledermatology	6
Time invested by dermatologist in a face to face consultation	10
Time spent by GPs to take clinical images	12.3
Time spent by GPs completing online information about referral (patient and disease information) and attaching clinical image.	6.7
Total time spent by GP in a consultation with teledermatology consultation	19
Time invested by a GP in a normal dermatology consultation	10

Table IV: Time Impact Study

Tables

Question	Yes	No	Doubts
Was there any organizational change due to teledermatology introduction?	4/10	6/10	0/10
Is the system really useful to solve the problems for which it was designed?	9/10	0/10	1/10
Is it effective for urgent situations?	9/10	1/10	0/10
Are you worried about patients' data confidentiality because of its transmission through the internet?	3/10	7/10	0/10
Would you recommend its use for daily consultations?	9/10	0/10	1/10

Table V: Physician's opinion results