Telemedicine in dermatology: Evaluation of secondary and tertiary teledermatology

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General Discussion
The field of dermatology was one of the first adaptors of telemedicine, dating back to 1995, and has one of the highest scientific output in the field of telemedicine.\textsuperscript{1-3} The research described in this thesis expanded on this scientific knowledge base by answering the following research questions:

1. What is the effect of a large-scale implementation of secondary teledermatology on efficiency, quality and costs of care when integrated in daily practice and applied following patient selection by the GP?
2. Can secondary care teledermatology be combined with dermoscopy images in a real world clinical setting?
3. Can the model of secondary teledermatology be applied to tertiary care models and what would be the effects on efficiency?

This chapter will describe the main findings of the thesis and compare them to results from current literature on teledermatology, point out strengths and limitations of the methods used and how these limitations could be overcome. Furthermore, it will provide general recommendations on the implementation of a teledermatology service and the applicability of the results to implementation in other countries and/or healthcare systems. Additionally it will explore how experiences in teledermatology research can aid in the implementation of telemedicine services in other specialisms, e.g. ophthalmology, pulmonology and cardiology. Finally, recent teledermatology research projects and possible directions for future research and implementation will be discussed.

**Main findings**

**Secondary Teledermatology**

Secondary teledermatology consultation is by far the most studied implementation of teledermatology. Studies on diagnostic accuracy, reliability and validity had already demonstrated that teledermatology is as effective as live visits.\textsuperscript{4,5} However,
full implementation of teledermatology services (teledermatology is completely integrated in regular care processes and has sustainable regular tariffs embedded in the healthcare insurance system) in healthcare systems has been lacking. This thesis showed that secondary teledermatology practiced on a large scale proved effective in an urban densely populated real world clinical setting, provided that patient selection for teledermatology is performed by the GP.

The results in this thesis showed that teledermatology, performed with the purpose of referral prevention, led to a 74% reduction in the number of physical referrals. Furthermore, teledermatology was performed in 29% with the purpose of second opinion (GP did not intend to refer the patient, but instead used teledermatology to gain advice). These patients were managed using the advice from the teledermatologist and 16% of these cases were physically referred on the request of the teledermatologist, thus increasing the quality of care. And finally, an 18% cost reduction compared to the conventional costs was estimated.

![Figure 1 - Teledermatology consultations and active GPs per year](source)

Source: KSYOS TeleMedical Centre Database, The Netherlands
Despite this successful implementation in The Netherlands where the use of teledermatology continues to grow (Figure 1), literature show few other examples of full implementation. In a recent survey amongst dermatologists in the USA the main reasons why dermatologists did not practice teledermatology were lack of (understanding of) a TD reimbursement system and possible increased medical legal risk. Nevertheless, in the USA, 36 active services have been identified over the last 5 years with an annual median consult volume per service of 309 (range, 5-6500) and all with a sustainable method of reimbursement. The Faroe Islands have had a running teledermatology program for 7 years and included 9161 teleconsultation. Reports on teledermatology in other countries continue to describe small regional or pilot size implementations.

No new results on prevented referrals or economic analyses of secondary teledermatology have been reported since the research described in Chapter 2 was performed. One study by Whited et al. reported on the effect of teledermatology on the quality of life. Compared to conventional care there was no significant difference found in skin related quality of life.

Teledermoscopy

The results in this thesis showed that, when teledermoscopy is used in a real world clinical setting where the GP is responsible for taking the dermoscopic picture, it had mediocre image quality. This led to a lower accuracy and reliability compared to in vivo examination. Compared to regular clinical pictures used in teledermatology, taking a dermoscopic picture requires more skills and time. Therefore it is more difficult to implement in a busy GP practice. However, high accuracy and reliability of a teledermoscopy service can be achieved under conditions that lead to high quality images suitable for assessment. The results in Chapter 3 showed that cases were high image quality was achieved the accuracy was comparable to in vivo assessment. Additionally,
New Zealand has a successful melanoma screening service with clinics for dermoscopic photography across the country receiving over 20,000 patients per year.\textsuperscript{15} In this setting a screening nurse especially trained in taking dermoscopic images was in charge of image acquisition. Also in Turkey a high accuracy was found recently, but again in this study all images were taken by the same technician.\textsuperscript{16}

**Tertiary Teledermatology**

Tertiary teledermatology (TTD) is far less prevalent compared to secondary teledermatology. Its main category of use is consultation of a specialized, often academic dermatologist on highly specialized cases. Other categories of use are resident training and continuing medical education.

The results in this thesis demonstrate that: (1) a tertiary teledermatology service has the potential to reduce physical referrals between general and academic dermatologists; (2) the tertiary teledermatology platform developed is feasible and usable; and (3) participating, and highly motivated, general and academic dermatologists accept such a system. The follow-up study, however, showed a lack of motivation in a larger group of general dermatologists to use tertiary teledermatology in this setting. The dermatologists indicated that despite important advantages such as fast response time, formalized records and data and privacy security, the current work process using telephone and email was preferred because of its ease of use and direct personal contact. The quantitative results, again, indicated that tertiary teledermatology could be used to improve triage between secondary and tertiary centres.

Conditions that could lead to successful implementations were indicated as: a) a national TTD system including all dermatologists indexed according their sub specialty, b) ability to send the TTD consultation to a dermatologist personally, c) ability to discuss a case with multiple dermatologists, d) connections to Electronic
Health Records, e) change in policies of tertiary centres or health insurers, in which they would stimulate the use of TTD consultation for all referrals and questions. No new results on tertiary teledermatology have been reported in literature since the research in Chapters 4, 5 and 6 was performed.

Strengths and limitations

Secondary Teledermatology

The study in Chapter 2 is the only teledermatology work reporting on such a large number of teleconsultations over 5 years, which supports the validity of the conclusions. In addition, all teleconsultations were performed during a real world clinical setting as the teledermatology service had already been implemented in regular healthcare before starting inclusion of subjects.

A shortcoming of this study is the absence of follow-up data on clinical and management outcomes of patients who received a teledermatology consultation. However, two randomized trials by Pak et al. and more recently by Whited et al. showed clinical outcomes of teledermatology with similar results compared to conventional care.17;18

As our cost evaluation had a limited focus, our results can only be generalized for a fully implemented teledermatology service in a similar setting. Primary care costs and societal costs (e.g. travel costs, absence of work) were not included. Initial investment costs (e.g. for hardware, software, training programs, full implementation, organisation as well as administration) were taken care of by the telemedicine provider and thus costs were included in an indirect way. Still, the costs formula used in Chapter 2 is applicable to other countries that have comparable health systems with a strong gatekeeper function of primary care and in more heterogeneous health care systems, such as the US, when an average price per diagnosis can be estimated.
The patient’s acceptance of and satisfaction with teledermatology was not in the scope of this thesis. However, multiple studies had already reported high patient satisfaction and acceptance with SAF teledermatology.\textsuperscript{19-27}

**Teledermoscopy**

The research described in Chapter 3 is one of the few studies of diagnostic agreement that have been conducted in a real-world clinical setting. It is the first study to report on the use of teledermoscopy in a general practice setting. Although the diagnostic reliability results are significant, the major limitation are the underpowered accuracy results, as the vivo diagnoses data set is incomplete due to patients not undergoing the physical referral. This could have been prevented by a longer inclusion period, including more GPs as participant and by stricter monitoring of the participating GPs in following the instructions to send the patients to see the dermatologist in vivo after the teleconsultation.

The authors classified the diagnoses made by the teledermatologist for analysis. This could have created an interpretation bias and could have been prevented if all teledermatologist were instructed to provide (aggregated) diagnoses according to a predefined classification.

**Tertiary Teledermatology**

One possible limitation in the pilot study (Chapter 5) was selection bias. The participating dermatologists were highly motivated and monitored. Consequently, it was unlikely that they would not accept TTD. Secondly, no follow-up data was available on whether or not patients were seen live by an academic dermatologist after TTD. Finally, patient acceptance and satisfaction were not measured in this pilot.

The study described in Chapter 6 included more participating peripheral dermatologists as compared to the pilot study (Chapter 5). Our findings on the
lack of motivation for tertiary teledermatology are underlined by the fact that only three peripheral dermatologists were responsible for 60% of the teleconsultations. This could create a selection bias in the patient population and therefore the quantitative results, but the main evaluation results from questionnaires and interviews were not influenced by this fact. Additionally, the low inclusion of TTDCs forms a limitation of the findings on referral prevention.

**Recommendations for teledermatology implementations**

This section provides some recommendations on conditions that can contribute to a successful teledermatology implementation. For every setting, dependent on the specific demands and challenges, a different combination of these conditions can prove most successful.

**Actors**

Implementing teledermatology usually entails changing the way people work. Even when all other conditions are met, if the actors of the telemedicine service are not involved from an early stage implementation is likely to fail. Chapter 6 of this thesis shows the importance of clear incentives and motivation for the actors. Likewise, when all actors are highly motivated, a telemedicine project can be very effective even under poor conditions. Examples of this are found in telemedicine projects in developing countries or harsh environments. Most important aspect is proper change management: before starting implementation, identify all actors and key stakeholders, define advantages for all of the actors and solutions for the challenges they could face. It is best to present the service as something that either the referrers (e.g. GPs) or the consultants (e.g. dermatologists) want as a group. Implement region by region and start with the most motivated actors. When the first results of the service in terms of performance indicators are positive,
have the actors themselves present these to all possible actors in the region to upscale the service. Project management of such an implementation should lay with either a dedicated telemedicine provider or dedicated professional from within one of the actor groups.

**Mode of delivery**

Although this thesis did not investigate different modes of delivery, recommendations can be made based on the literature found during the study period. Store and Forward (SAF) is the most prevalent mode of delivery\(^3\) and also the recommended mode because of the advantages it holds over Real-Time (RT) delivery. There is no significant difference found in accuracy and reliability between the two.\(^4,5,32\) Implementing SAF is less demanding for the following reasons:

- SAF capturing technology remains far cheaper than RT capturing technologies.
- SAF capturing technology is easier to use than RT as there is only need for taking and uploading several pictures at one point in time versus a continuous use of video equipment, video conferencing software and network connection.
- SAF is truly space and time independent whereas RT is only space independent, putting more strain on the actors’ schedule.
- SAF automatically creates a lasting clinical record, whereas RT needs added functionality to record the session. In terms of data storage RT also has the disadvantage, as video needs substantially more storage space compared to a photograph.
RT can be preferred over SAF in a specific setting e.g. where the service requires interaction between patient and teledermatologist, where the examined skin covers a very large part of the body or when direct results are required.

**Capturing technology**

As digital photo cameras are increasingly improving in output quality and decreasing in price, currently essentially all cameras on the market are suited for teledermatology. Even most mobile phone cameras have sufficient quality to be eligible for teledermatology use.\(^{33-36}\) More important, as stated under the Actors section, is the person handling the camera. Proper training and repetition in taking clinical pictures should be mandatory for all who practice teledermatology.

Teledermoscopy capturing technologies are still very much in development, ranging from camera adapter pieces, all-purpose microscopes to camera stations specifically designed for dermoscopy. Depending on the purpose (e.g. lesion screening centre or GP with special interest), a suitable device can be acquired. As described in Chapter 3 taking a dermoscopic image has proven to be more difficult than macro images, thus the training and repetition of these skills should increase as well. A possibility could be to train the technical assistant in a GP practice in dermoscopy photography, analogous to the tasks they perform in ECG and spirometry measurements.

It is recommended that dermatologists be offered the option to provide feedback on the quality of the clinical pictures and the dermoscopic pictures. The telemedicine provider (see below) could monitor these quality results and provide extra training programs when needed.

**Purpose and setting**

Depending on the purpose of the teledermatology service, the work processes and actors that are affected by implementation of the service are different, e.g. GP
and dermatologist or dermoscopy nurse and dermatologist. One should define the purpose beforehand and pick a suitable set-up (i.e. software and hardware) accordingly, in close collaboration with the most involved actors. Specify what part(s) of the affected work processes are changing due to the teledermatology service and educate and motivate all actors to adhere to these changes.

Health care systems are usually regulated on a national level. Differences in these healthcare systems can be of influence on the teledermatology service e.g. whether primary care performs as a gatekeeper to secondary and tertiary care. If this is the case, consultation and triage purposes are more easily implemented as all patients first visit primary care. In settings where patients can go directly to a specialist, a patient supplied teledermatology service for triage could be more successful.

**Integration in health information infrastructure**

A telemedicine service will very often, if not always, be used by actors in different tiers of healthcare, in different institutions and different specialties. This leads to a divers landscape of all different Electronic Health Records (EHRs) used by the actors of the telemedicine service. In The Netherlands, for example, there are currently 8 major GP EHRs, 12 hospital EHRs and 5 EHRs for specific patient groups (e.g. COPD, diabetes) that provide records to an intermural team of healthcare professionals. Alongside those are the EHRs of the pharmacists, physiotherapists, psychologists and so on.

A telemedicine service that is completely integrated with some, but preferably most of these systems (concentrated on the ones used by the telemedicine actors), will have a far better chance of reaching a large-scale implementation. Integration can be divided into three phases:
I. Result reporting in all relevant EHRs.

All results from e.g. a teledermatology consultation should be placed in the EHR of the GP that started the teleconsultation and in the EHR of the dermatologist that answered the teleconsultation. At the minimum represented by text, but preferably including the clinical images.

II. Single sign-on from all EHRs.

As most telemedicine services today are some form of web application, the actor should be able to log in to the telemedicine platform directly from their main EHR. As they are already identified and authenticated through the log in procedure of their EHR, these credentials can be transferred to the telemedicine platform, ensuring increased usability of the system via a one-click solution. Added functionality would be the option to remember the patient context of the current record in the EHR when transferring to the telemedicine platform, discarding the need to look up the same patient again.

III. Full integration within EHRs.

Finally, all telemedicine functionality should be integrated in the EHRs themselves, including the proper standards providing the possibility of communication between different EHRs. This provides an actor with one system they would use, bringing many advantages e.g. singly point of entry for identification and authentication, access to all patient data including the option to easily add the relevant data (e.g. medication history) to the teleconsultation and complete reports of teleconsultations.

Using a dedicated telemedicine provider

A recent survey amongst US based teledermatology practising clinicians listed the challenges they faced in their teledermatology practices: Obtaining
reimbursement, resolving technical-related issues, communicating with referring providers, setting up TD operation, and setting up TD staff education programmes. Dermatologists who do not practice teledermatology report similar challenges, plus the possible medical-legal risks involved. These challenges to a successful implementation can be overcome when a care institution (or commercial company) acts as a dedicated telemedicine provider, thus providing a single organisation that manages all these issues and is also the point of contact for patients, care professionals and actors such as government and supervisory bodies. The responsibilities and tasks that a telemedicine provider can (and maybe should) incorporate to set up a telemedicine service are:

- Administration, registration and storage of clinical records
- Negotiating sustainable reimbursement with healthcare insurers
- Handle claiming and crediting incorrect claims
- Imbursement of involved actors (e.g. dermatologist, general practitioner and telemedicine provider staff)
- Providing clinical liability insurance specifically tailored to telemedicine procedures
- Proving a telemedicine software platform and keeping it up to date in concordance with the latest security standards, legislation and regulations.
- Providing suitable hardware for telemedicine procedures (e.g. cameras, dermoscopes)
- Providing CME accredited training programs for the medical staff (e.g. taking clinical pictures, using the telemedicine platform, assessment of skin lesions via telemedicine)
- Providing project management for telemedicine implementation in a region
- Providing helpdesk-service for technical and administrative issues
- Providing yearly reports on performance indicators (e.g. per clinic)
• Providing integration with Electronic Health Records (EHRs) for both GPs and specialists
• Negotiating and developing communications standards together with EHR providers and other (governmental) actors.

In essence, the telemedicine provider does not differ from a regular hospital or care institution, other than the absence of the iconic large building with examination rooms and wards.

**Health Management Practice**

The powerful factor in success stories in teledermatology implementation is the cooperation of both scientific institutes (public sector) and commercially driven companies (private sector). This collaboration has played a large role in the data collection for the research in this thesis, particularly for Chapters 2 and 6. This combination proves to be a driving force in the evolution of TD and this practice model, described by Witkamp and Van der Heijden as “Health Management Practice” (see textbox) explains the process in which private (e.g. telemedicine provider or hospital) and public parties (e.g. ministry departments or disease specific funds) and independent knowledge institutes (e.g. universities or research centres) jointly develop and study telemedicine tools and their outcomes and drive introduction of telemedicine services in regular care.37
Health Management Practice

Telemedicine Development
Technology combined with new healthcare processes lead to an integrated telemedicine service including software, hardware, infrastructure, hosting, education and management, all meeting (national) requirements of safety, security, connectivity and user friendliness.

Health Management Research
Independent research aiming to collect evidence that the use of telemedicine services increases efficiency leading to increased production volume and better quality of care at equal or lower costs.

Health Management Implementation
Telemedicine stakeholders - manufacturers, users, policy makers and health insurers - should all be actively involved in the design of practice and reimbursement models. When significant reductions in costs on a macro level have been proven, the next step is to create a healthy business case to support the complete telemedicine service. In order to assure successful implementation in regular care, active support and marketing from all stakeholders should take place.

Teledermatology: blueprint for new telemedicine services

When a telemedicine service has been successfully implemented, the experiences and knowledge gained during this process can be used in the implementation of telemedicine services in others fields. Especially when a dedicated telemedicine provider has managed the implementation, thus keeping all knowledge in one place, this model could be very effective.

At the core of the teleconsultation process lays the digitization of a measurement, making it suitable for electronic data transfer. To assess if the teledermatology model is generalizable to another medical specialty this is the first and most important question to address. For teledermatology, obviously a visual measurement (looking at a skin disorder), was made digital by taking a digital photograph of the skin. This can easily be applied to other visual measurements such as fundus photos in ophthalmology or inner ear photos in otolaryngology and also to other graphical represented measurements such as spirometers in pulmonology and ECGs in cardiology. Looking beyond images and graphical representations, one could imagine kidney function results from Point of Care Testing (laboratory diagnostic testing performed at or near the site where clinical care is delivered) at the GP practice that could be sent as digitized tables. Even an automated advice from a GP decision support system could be used as a measurement (e.g. advice on medication prescription or deviation from standard treatment plans), when that advice is controversial and the GP would want to discuss it with a specialist.

Secondly, the motivators for the different actors that were essential to the success of teledermatology (e.g. educational effect, improved patient service, reimbursement, improved professional network between GP and dermatologists) could be generalizable to other newly developed teleconsultation services in a different specialty. Teleconsultation services are found in e.g. psychology,
cardiology, ophthalmology and pulmonology. As Chapter 6 has shown, it proves very difficult to successfully implement a new telemedicine service when motivators are not present or too weak to induce change in work processes.

Example from practice

In The Netherlands, KSYOS TeleMedical Centre is an example of a telemedicine provider that operates on a national scale as an online hospital and incorporates most of the recommendations made in this chapter. Their telemedicine services show how a successful implementation of teledermatology in 2005 led to implementations of new teleconsultation services. In 2007 tele-ophtalmology, in 2009 telecardiology and in 2010 telepulmonology were introduced. These services currently have had approximately 15,000, 13,000 and 4,000 teleconsultations respectively. In tele-ophtalmology 45% of referrals to the ophthalmologist are prevented. In telepulmonology and cardiology these figures are 56% and 74% respectively. Newly developed services are e.g. tele-otolaryngology, telenephrology, telepsychology and tele-ultrasonography.

Generalizability can also become more difficult when healthcare systems are different, e.g. teledermatology benefitted greatly from the gatekeeper function of the GP in The Netherlands. This system is also present in the UK for example and therefore susceptible for the same motivators. France and Belgium, however, have a system in which a major part of the patients go directly to the dermatologist without visiting a GP first, making it more difficult to apply the same motivators to a telemedicine service in these countries.
Recommendations for future research

Secondary Teledermatology
The results in Chapter 2 on prevented referrals were based on qualitative data (measurement of the management plan according to the GP) and no other large implementation studies have been performed on referral prevention that measured actual referrals after teledermatology had taken place. It would be of interest to register all the received dermatology care for a year in a population that also received teledermatology consultation. This can be done e.g. by linking the database of a telemedicine provider with the database of the national registration of all insured care transactions. In the healthcare system in The Netherlands all insured care transactions are based on diagnosis and treatment combinations and are coded as such. Therefore, it would be possible to find whether a person that received a teleconsultation also received care from a dermatologist for the same diagnosis in a certain period of time after teleconsultation.

A second important and interesting question is whether a decline in referrals to the dermatologist over the years can be found in GP practices that actively performed teledermatology and whether this decline would be absent in GP practices who have not performed teledermatology. There are national databases with random sampling of Dutch GP practices in which referrals are measured. Connecting telemedicine provider data with these databases can provide the possibility to answer this question. If this hypothesis were true, it would show a long-term effect of teledermatology and underline the educational effect that is experienced by the GPs.

Clinical outcomes of teledermatology consultations have been subject to little research, although results of two studies indicate that teledermatology has similar outcomes compared to in vivo consultation. When a large number of
teledermatology consultations are performed in a real world clinical setting as shown in Chapter 2, the hypothesis that clinical outcomes lead to proper patient management is easily made. Still, there is a lack of scientific evidence to confirm this hypothesis based on a large heterogeneous population, and it remains an important question to answer in the secondary teledermatology research domain. Economic evaluations remain difficult to perform in the field of telemedicine.\(^{47}\) However, it is essential to provide stakeholders with solid arguments whether or not to implement a telemedicine service. Further research can be based on actual costs derived from the health care insurance companies (or national registrations thereof) combined with clinical outcomes on effectiveness in different settings.

Mobile teledermatology is the most recent addition to the domain of teledermatology.\(^ {48}\) Also known as M-Health, the use of mobile communication technology has entered the telemedicine world.\(^ {49}\) This encompasses a broad field of applications using smartphones, tablets and other wireless internet devices that have been developed in the last four years and by far surpass the technologies used in most studies from the last decade. But although technologically the possibilities are numerous, additional research needs to show if and in what settings mobile teledermatology can lead to better, faster care with lower cost.

**Teledermoscopy**

Although diagnostic accuracy and reliability have been shown to be comparable to in vivo in many implementations where one or a few skilled individuals were responsible for taking the dermoscopy images, the results in Chapter 3 showed that teledermoscopy in a GP practice setting cannot be compared to these aforementioned implementations. Further research should determine in which settings the implementation of teledermoscopy can add to the quality and efficiency of care and try to identify the required conditions for a successful teledermoscopy implementation.
Tertiary Teledermatology

Digital communication between dermatologists, and specialists in general, will continue to grow. Although this thesis showed a specific setting where the use of a teledermatology implementation to streamline and improve this intercollegiate communication was not successful, it is still necessary to think about the way we handle digital communication when the subject is of a clinical nature. Issues addressing patient privacy, information security, availability and validity of information remain important issues when exchanging clinical information. In addition, triage between hospitals and within different departments of hospitals might benefit by using telemedicine applications (embedded in EHRs).

Conclusions

Today, teledermatology is a permanent part of dermatologic care. Secondary teledermatology where patient selection is performed by the general practitioner should, given the proof of its successes presented in this thesis, be added as a best practice to guidelines directing primary dermatologic care. Successful implementation of telemedicine services is only possible when all involved actors are motivated to use the telemedicine service and the motivators are sustainable, enabling the service to surpass the pilot phase and ensuring the service will become a permanent part of the care process and embedded in the healthcare system.
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