Telemedicine in dermatology: Evaluation of secondary and tertiary teledermatology
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Tertiary Teledermatology: A Systematic Review


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Abstract

Objective: Telemedicine is becoming widely used in healthcare. Dermatology, because of its visual character, is especially suitable for telemedicine applications. Most common is teledermatology between general practitioners and dermatologists (secondary teledermatology). Another form of the teledermatology process is communication amongst dermatologists (tertiary teledermatology). The objective of this systematic review is to give an overview of studies on tertiary teledermatology with emphasis on the categories of use.

Methods: A systematic literature search on tertiary teledermatology studies used all databases of the Cochrane Library, MEDLINE (1966 - November 2007) and EMBASE (1980 November 2007). Categories of use were identified for all included articles and the modalities of tertiary teledermatology were extracted, together with technology, the setting the outcome measures and their results.

Results: The search resulted in 1377 publications of which 11 were included. Four categories of use were found: getting an expert opinion from a specialized, often academic dermatologist (6/11), resident training (2/11), continuing medical education (4/11) and second opinion from a non-specialized dermatologist (2/11). Three modalities were found: a teledermatology consultation application (7/11), a website (2/11) and an email list (1/11). The majority (7/11) used store-and-forward and 3/11 used store-and-forward and real-time. Outcome measures mentioned were learning effect (6), costs (5), diagnostic accuracy (1), validity (2) and reliability (2), patient and physician satisfaction (1) and efficiency improvement (3).

Conclusion: Tertiary teledermatology's main category of use is getting an expert opinion from a specialized, often academic dermatologist. Tertiary teledermatology research is still in early development. Future research should focus on identifying the scale of tertiary teledermatology and on what modality of teledermatology is most suited for what purpose in communication among dermatologists.
Introduction

In the last decade, telemedicine has become widely used in healthcare. Its ability to provide care to remote regions and to consult specialists has proven to be an efficient and cost effective addition to the medical process.\(^1\)

The most common form of the teledermatology process is digital communication between general practitioners and dermatologists.\(^2\) This is referred to as secondary teledermatology. Another form of the teledermatology process is digital communication amongst dermatologists, referred to as tertiary or specialized teledermatology. In a recent systematic review the maturity of evaluation studies conducted in teledermatology was summarized\(^5\), however no distinction was made between secondary and tertiary teledermatology. Having only been mentioned very briefly in reviews, it is not clear what its value is.\(^3\);\(^6\)

The objective of this systematic review is to give an overview of studies on tertiary teledermatology with emphasis on the categories of use, in other words, for what purposes tertiary teledermatology is used. Categories of use for tertiary teledermatology are, e.g., training of residents, continuing medical education (CME) and expert opinion. Second, it describes the modality, technology, setting, outcome measures and results of the studies. Third, we were interested in whether tertiary teledermatology showed differences compared to secondary teledermatology on modality, technology and outcome measures.

Background

Dermatology is most suitable for the use of telemedicine applications, because of its visual character. Two technologies of teledermatology have been developed: real-time (RT) and store-and-forward (SAF). In RT teledermatology, which is time and place dependent, a live video-link between the patient accompanied by a care professional (e.g. general practitioner, dermatology-trained nurse) and the
dermatologist is created, allowing the dermatologist to interact directly with the health provider and the patient. SAF teledermatology uses digital images of the patient combined with textual information. These digital consults are sent to and reviewed by a dermatologist and an answer is provided to the referring clinician or patient. SAF is time and place independent. For both SAF as RT, the diagnostic reliability and accuracy of teledermatology are comparable to live visits.¹

**Methods**

**Search Strategy**

A systematic literature search was performed to select any study on tertiary teledermatology using the following databases: MEDLINE (1966 - November 2007), EMBASE (1980 - November 2007), all databases of the Cochrane Library.

The following search query was used for the MEDLINE and EMBASE databases, without limitations on the year of publication or the language:

("Medical Records Systems, Computerized"[Mesh] OR teledermat* OR telemedicine OR teleconsult* OR e-health OR electronic mail) AND (dermatol* OR skin*)

For the search in the Cochrane Library the keywords ‘medical records systems’ and ‘electronic mail’ were left out as the search results including these keywords were too broad and not on topic.

In addition, SCOPUS was used to find the publications that cite one or more of the references of the recently published systematic review by Eminovic et al.⁵ Duplicates were excluded. As we were interested in all kind of articles on tertiary teledermatology, we did not exclude any specific study type or publication type. Besides original research, comments, letters and editorials could be included. Conference proceedings and errata were excluded.
Selection Process

In the first step, a title scan, references were included if one of the words ‘teledermatology’, ‘dermatol*’, ‘skin*’ was found in the title. References with the word ‘telemedicine’ in the title were only included if no specialty (other than dermatology) was mentioned in the title.

In the second step, titles and abstracts were scanned and included if specialist-to-specialist communication using teledermatology was mentioned. All references without an abstract in the database were subject to a second title scan. These references were only included if the title included the word ‘teledermatology’.

In the third step, the full text of the database was subject to a second title scan. All references were included if the main subject of the article was the use of teledermatology between a dermatologist, or a dermatology resident and a specialized dermatologist. If the referer was a primary care physician or specialist other than a dermatologist, the article was excluded.

Data extraction and Analysis

Categories of use were identified for all included articles, and the modalities (the software package) of tertiary teledermatology were extracted. Data was extracted on the technology (SAF or RT), the setting (national or international), type and number of participants, number of cases, in case of an evaluation the outcome measures used (diagnostic accuracy, diagnostic reliability, image quality, efficiency, improvement, costs, patient satisfaction, physician satisfaction and learning effect) and, if available, their results.

Two main study designs were distinguished: descriptive studies (describes an occurrence by its parameters) and analytic studies (examines causal associations).

We subdivided the analytic studies in intervention studies (researcher intervenes) and observational studies (no interaction).
on one or more factors to study its effects) and observational studies (researcher does not intervene, only observes and records all results).
It was determined whether meta-analysis was possible based on the homogeneity of the included studies.
Two reviewers (JvdH, PhS) checked the second and third step of the selection process independently, as well as the data extraction. In case of disagreement, discussion was used to reach consensus.

**Results**

**Search Strategy**
The search resulted in 667 references from MEDLINE and 214 references from EMBASE. The search in the Cochrane Library resulted in 68 references. With SCOPUS we found 818 references citing the reference list of the systematic review by Eminovic et al.\(^5\) The total amount of references found was 1767. After removal of duplicates, a total of 1377 remained.

**Selection Process**
The selection process is summarized in Figure 1. After all the selection steps, 10 full text articles and 1 letter were included. Most articles (n=20) were excluded because no teleconsultations to a dermatologist were made. Fifteen articles were excluded because the referring clinician worked in primary care.
Chapter 4 – Tertiary teledermatology: a systematic review

Figure 1: Selection process
**Data Extraction and Analysis**

Data was extracted from 11 articles.\(^7\)–\(^{17}\) Five studies were observational.\(^7\)–\(^{14}\)–\(^{17}\) Six studies were analytic, one was a controlled intervention study\(^{13}\), and the other five were descriptive studies.\(^8\)–\(^{12}\) No randomized controlled trials were found.

The studies were clinically very heterogeneous and mostly qualitative which hampers a meta-analysis or any other quantitative analysis.

Table 1 describes per modality the category of use, in which setting the teledermatology system was used, the technology, the number of participants and the number of cases.

**Table 1: Per modality, the category of use, technology and setting**

<table>
<thead>
<tr>
<th>Category of use</th>
<th>Technology</th>
<th>Setting (# of countries)</th>
<th>Participants</th>
<th>Patients / Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Website</strong> (^7),(^9),(^12),(^14)</td>
<td>2</td>
<td>Expertise/CME</td>
<td>SAF</td>
<td>International (45)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expertise</td>
<td>SAF</td>
<td>International (33)</td>
</tr>
<tr>
<td><strong>Email list</strong> (^9)</td>
<td>1</td>
<td>Second opinion/CME</td>
<td>SAF</td>
<td>International (&gt;52)</td>
</tr>
<tr>
<td><strong>Teledermatology application</strong> (^7),(^9),(^11),(^12),(^15),(^17)</td>
<td>7</td>
<td>Training</td>
<td>SAF</td>
<td>National (USA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Training</td>
<td>SAF</td>
<td>National (USA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CME</td>
<td>SAF</td>
<td>National (USA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expertise/CME</td>
<td>SAF &amp; RT</td>
<td>National (Switzerland)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expertise</td>
<td>SAF &amp; RT</td>
<td>International (2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expertise</td>
<td>SAF</td>
<td>International (2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expertise</td>
<td>SAF &amp; RT</td>
<td>International (?)</td>
</tr>
<tr>
<td><strong>Other</strong> (^8)</td>
<td>1</td>
<td>Second opinion</td>
<td>Not Available</td>
<td>National (Germany)</td>
</tr>
</tbody>
</table>
Categories of use

Based upon the included articles, four categories of use of tertiary teledermatology were identified:

1. **Expertise**, where advice is sought from a dermatologist specialized in a specific field, was seen most. Lozzi et al. showed the additive value of specialized teleconsulting, since in 30.3% of the cases the correct diagnosis was made through teledermatology with a specialized dermatologist, while the live consultation with a dermatologist was erroneous.\(^{13}\) Another study used teledermatology between a regional dermatology centre in Africa and a Swiss university dermatology department.\(^{17}\) Other studies describe similar use of teledermatology to contact specialized.\(^{7;11;12;14}\)

2. **Continuing medical education** was seen in four articles. Through internet fora, bulletin boards or email lists, dermatologists could learn and benefit from the work done by others in their field. Several initiatives for this purpose date back to the DERM/INFONET system developed in 1988.\(^{10}\) More recent examples are Dermanet, a Swiss communication suite used by all academic hospitals in Switzerland\(^{11}\), Virtual Grand Rounds in Dermatology, an American website with just under 200 international participants\(^{12}\) and RxDerm-L, an email discussion group with over a thousand subscribers world-wide.\(^{9}\)

3. **Supervision of residents** through teledermatology in training programs. At a medical centre in New York dermatology residents in the urgent care clinic performed examinations without an attending physician present. Supervision was established through a SAF teledermatology system.\(^{15}\)

4. **Second opinion**, where advice is sought from a non-specialized dermatologist, was seen in one article. By use of the email list discussion group, dermatologists could not only get advice from specialized dermatologists, but also other non-specialized dermatologist could offer
Furthermore, a survey amongst dermatologists in private practice showed that 59% of the respondents do prefer teledermatology as the way of communication amongst each other. Eighty-two percent of the respondents intended to use teledermatology to communicate with dermatology clinics.

**Modality, Technology and Setting**

The modality of the teledermatology systems varied, six used a teledermatology consultation system, which uses either web-based system or a software package with connection to the Internet to provide secured communication. Two used websites with a forum or bulletin board dermatologists could visit to look up information, view interesting cases and post questions, and one used an email list discussion group in which all subscribers could participate. The majority (7/11) of the studies used SAF only. Three studies used SAF as well as RT, although no comparisons were made between the two technologies in any of these studies. None of the studies only used RT. In one study, it was not clear what technology was used.

The setting, number of participating dermatologists and the number of cases included in the study can be found in Table 1.

**Outcome Measures and Results**

As most study designs had a descriptive or observational nature, their outcome measures and results had a descriptive nature. The outcome measures most often mentioned in the studies were learning effect and costs (Table 2). Learning effect was not measured in a quantitative way, but the studies qualitatively described that a learning effect was experienced by the participants through, for example, the refreshing of old knowledge and the sharing of new concepts, a dermatological quiz and the presentation and discussion of difficult cases. Cost aspects...
were mentioned in 5 studies. No study performed a cost analysis, The studies only reported the costs of development or how the projects were funded.\textsuperscript{9,12,14,15,17}

\begin{table}[h]
\centering
\caption{Prevalence of outcome measures in included studies}
\begin{tabular}{|l|c|}
\hline
Outcome measure & \# of studies \\
\hline
Learning Effect & 6 \\
Costs & 5 \\
Image Quality & 3 \\
Efficiency Improvement & 3 \\
Diagnostic Validity & 2 \\
Diagnostic Reliability & 2 \\
Diagnostic Accuracy & 1 \\
Patient Satisfaction & 1 \\
Physician Satisfaction & 1 \\
\hline
\end{tabular}
\end{table}

Diagnostic accuracy, validity and reliability, were measured in four studies. Diagnostic accuracy was measured by comparing telediagnosis to histopathological diagnosis and resulted in a 78.8% accuracy rate in teledermatology.\textsuperscript{13} Two studies reported that diagnostic validity was not ensured since expert criteria were not defined and therefore every person could actively participate without any validation of their expertise.\textsuperscript{9,14} One study reported that diagnostic reliability was not measurable as no independent dermatologists had diagnosed the cases.\textsuperscript{13} One study reported a 96% diagnostic concordance rate. However, the study was directed to proof teledermatology could be used to supervise residents and the teledermatologist therefore already knew the diagnosis made by the resident prior to making their own diagnosis.\textsuperscript{15}
Patient and physician satisfaction were both reported once. In the study in which patient satisfaction was measured, it was the sole focus of the study. Satisfaction was measured by means of a survey. The satisfaction reported was high (93% of respondents were satisfied). Referring physician satisfaction was measured through a rating provided by physicians asking for a teleconsult. The rating reported was 3.9 out of 10 but the measurement scale and its meaning were not reported. The receiving physicians were said to be satisfied with the system, but no quantitative data or measurement methods were reported in this study.

Efficiency improvement (preventable referrals, better triage, less time spent per patient) was reported in three studies. Two studies reported that efficiency improvement could not be found, one study reported that teledermatology could add value to the management of challenging skin diseases, but no specification of what the added value encompasses was given.

Comparison with secondary teledermatology

The modalities used in secondary teledermatology are the same as are used in tertiary teledermatology. No comparison could be made as no review of the different modalities in secondary teledermatology exists.

In tertiary teledermatology all studies used SAF (n=10, one could not be determined) and some also used RT (n=3). Store-and-forward and real-time are used in 63 % and 29 % respectively in secondary teledermatology studies.

Compared to secondary teledermatology, we see few studies on diagnostic accuracy and reliability outcome measures in tertiary teledermatology. Only in 4 studies diagnostic accuracy, validity and reliability were tested. Recent reviews show diagnostic accuracy to be the most often used outcome measure to evaluate secondary teledermatology and one would expect this to be high in tertiary teledermatology as well. An explanation could be that because of the positive findings in secondary teledermatology on diagnostic accuracy and reliability, it is
assumed that the same quality can be found in tertiary teledermatology as well. Efficiency and satisfaction were not reported on in most tertiary teledermatology studies. In secondary teledermatology, satisfaction (doctor and patient) has been a subject of half the studies found in a recent review.\(^5\) Physician satisfaction with a new tool like teledermatology is very important; the success of a new system heavily depends on the support of the physicians who are the potential users of the system.\(^{18}\)

**Discussion**

Tertiary teledermatology’s main category of use is getting an expert opinion from a specialized, often academic dermatologist. Other categories of use are resident training, continuing medical education and second opinion for a non-specialized dermatologist. Three modalities have been presented, most used was a teledermatology consultation application, which uses the Internet to transfer the data.

The value that teledermatology adds to communication between dermatologists can be seen in several aspects, one major aspect is improved accessibility to specialized dermatologists leading to prevented referrals and shortened waiting lists. Secondary teledermatology has been broadly introduced in the Dutch healthcare system with approximately 50% of the general practitioners in The Netherlands using teledermatology. One randomized controlled study reports a reduction of 20% of physical referrals to the dermatologist due to teledermatology.\(^{19}\) However, in this study, the general practitioner performed no selection for teledermatology; all dermatological patients were subjected to teledermatology. A prevention of 53% is reported in another study where the general practitioner selects patients for teledermatology.\(^{20}\) These numbers could also apply to tertiary teledermatology.
Other benefits are easier international cooperation and sharing of knowledge more possibilities for training of residents and medical students and a more secure and structured way of communicating medical data. Overall, tertiary teledermatology seems to follow the same development track as secondary teledermatology has; SAF is more used than RT, there are mainly pilot studies being performed and cost analyses prove to be difficult to perform. Unfortunately, rigorous studies evaluating the benefits of tertiary teledermatology are lacking.

There are several shortcomings to this review. First, the search in the Cochrane library was done with a smaller search strategy as compared to the searches performed in the MEDLINE and EMBASE databases. Therefore it might be possible that some articles were not found. We looked at 50 randomly selected references from the original search in Cochrane and found no articles that met the inclusion criteria of step 1. Second, because of the lack of intervention studies found, the reported outcome measures are not as solid as outcome measures would be in studies with an experimental setting. In the descriptive and observational studies the outcome measures reported were more a qualitative description of the parameters than a quantitative measurement. And third, it is likely that this review underestimates the use of tertiary teledermatology going on in practice, since many teledermatology projects are implemented without any coverage in literature.

Future research should focus on identifying the scale of tertiary teledermatology further by e.g. a prospective survey among dermatologists. Furthermore, to use the full potential of tertiary teledermatology, we must gain a better understanding of what type of teledermatology to apply in a certain setting. Although only 11 articles were included, at least 3 different modalities have been described. Focus should be on what modality of teledermatology is most suited for what purpose in communication among dermatologists, what security measures should be taken and how to ensure the quality of the information provided.
Based on the results found in this review we will try to give a direction on what we think a good tertiary teledermatology system should look like:

1. Pictures with a resolution of 1.2 megapixels is sufficient for diagnosis.\(^{21}\)
2. The design of the system should be web-based as it is the most accessible.
3. Email is not safe enough and an intranet or stand-alone application is in most cases not accessible enough.
4. The system should have login/password entry for all users to ensure identification and use certificates to confirm trust between user and system.
5. Data should be stored in a database with a firewall protected server and should be backed-up daily.

The field of teledermatology research is still young, with steady publication output only since 1998.\(^4\) With the growing demand on specialist care within a growing and more demanding global population tertiary teledermatology should become part of regular healthcare.
Reference List


