UNIVERSITY OF GOTHENBURG

THE SAHLGRENSKA ACADEMY

Commercial mobile teledermatology – A solution for everyone?

Degree Project in Medicine

Malcolm Barknell

Programme in Medicine

Gothenburg, Sweden 2017

Supervisor(s): Alexander Börve, Lykke Barck, Olle Larkö

Department of Dermatology and Venereology, Sahlgrenska University Hospital

Abstract

BACKGROUND: With skin cancers being among the fastest growing cancers in Sweden, it has lead to increased pressure on dermatology clinics everywhere in the country. Standardized care processes have improved the situation regarding malignant melanoma and squamous cell carcinoma, however general dermatologic issues remain. Several studies have been made on teledermatology, many of them with promising results such as shortened time to treat, unnecessary visits skipped, planning easier and triaging possible. A logical evolution of teledermatology is a mobile form, mobile teledermatology. Studies have been made on this as well, however results not as precise as the regular form, although it has been suggested to work as a tool for triaging.

AIM: To investigate whether a direct to consumer mobile teledermatology system can triage users correctly to the nearest dermatology clinic for further tests, diagnosing and the right treatment and save time.

METHOD: In 2017, 766 patients used a teledermatology application, out of these 262 were recommended to use the application to send a self-referral to nearest dermatology clinic, 105 users sent a self-referral through this application, these were followed up. For comparison 120 primary healthcare center referrals and 120 regular self-referrals were obtained. The priorities given to each referral were compared, time until first visit in days within each assessment and specific diagnoses, and as well time until treatment were compared.

RESULTS: The difference in distribution of assessments was statistically significant when the teledermatology self-referrals were compared with regular self-referrals. The difference remained statistically significant when all three groups were compared.

There was a statistically significant difference in days waited between all three groups when prioritized as 2-4 weeks and 1-3 months, however this only implies that there was a significant difference in waiting times between all three groups. Thus teledermatology referrals were compared separately to each group, and days waited were only significantly lower compared to primary healthcare referrals in 2-4 weeks priority. However there were no statistically significant difference in days waited was found in any other priorities or diagnoses between the groups.

CONCLUSION: From data obtained, using a mobile teledermatology application may lower the amount of rejected referrals and at the same time find patients with lesions in more need of specialist care. Patients with regular self-referrals got an appointment faster than all other groups of all priorities analyzed however these type of referrals were rejected the most as well. The teledermatology referrals had slightly longer waiting times with a lower percentage of rejected referrals, although a significant difference was only found in one priority (2-4 weeks).

KEYWORDS: Mobile teledermatology, Referral, Triage

Table of contents

Abbreviations

BCC	Basal cell carcinoma
DCH	Diagnostiskt centrum hud
FTF	Face-to-face
KUH	Karolinska university hospital
MM	Malignant melanoma
NUH	Norrland university hospital
PHC	Primary healthcare center
SAF	Store and forward
SUH	Sahlgrenska university hospital
TD	Teledermatology
TDA	Teledermatology application
TDR	Teledermatology referral
TDS	Teledermoscopy

Background

Introduction

Skin diseases in Sweden and in Western countries in general are a growing concern, specifically skin cancers as these have an annual growth of 6% (1). A reason for this is because of our sun-habits and light skin type of the Swedish population, which are two major risk factors to develop cutaneous cancer (2). These sun habits include vacations to sunny locations, sunbathing in Sweden and use of sun beds (3-5). As these are among the fastest growing cancers, which include malignant melanoma and squamous cell carcinoma, dermatology clinics all over Sweden have to deal with increased pressure and queue times.

With the implementation of standardized care processes (Standardiserade vårdföropp, SVF (6)) the hope is to decrease waiting times and to treat skin cancers early. However patients diagnosed with general skin diseases are left out and sometimes wait longer than three months to visit a dermatologist (7, 8). Thus, other solutions for all conditions that can reduce waiting times needs to be explored.

The Current system

As of now the way to see a dermatologist in the public healthcare system is through a "gatekeeper" system. The primary care physician, at a primary health care centre (PHC), makes a judgement if a patient should be referred to a dermatologist. These referrals include information in text form and are normally sent by paper through traditional post or fax, these do normally not include photographs of the lesion of concern. Another way is through self-referrals available on web pages of hospitals in Sweden. Though many of these ends up rejected (non-prioritized/0-assessed) due to lack of information, and are instead instructed to

seek care at a PHC. With the development of todays technology teledermatology (TD) is available of use for the general public. These different pathways are displayed in the flow chart below (Figure 1.).

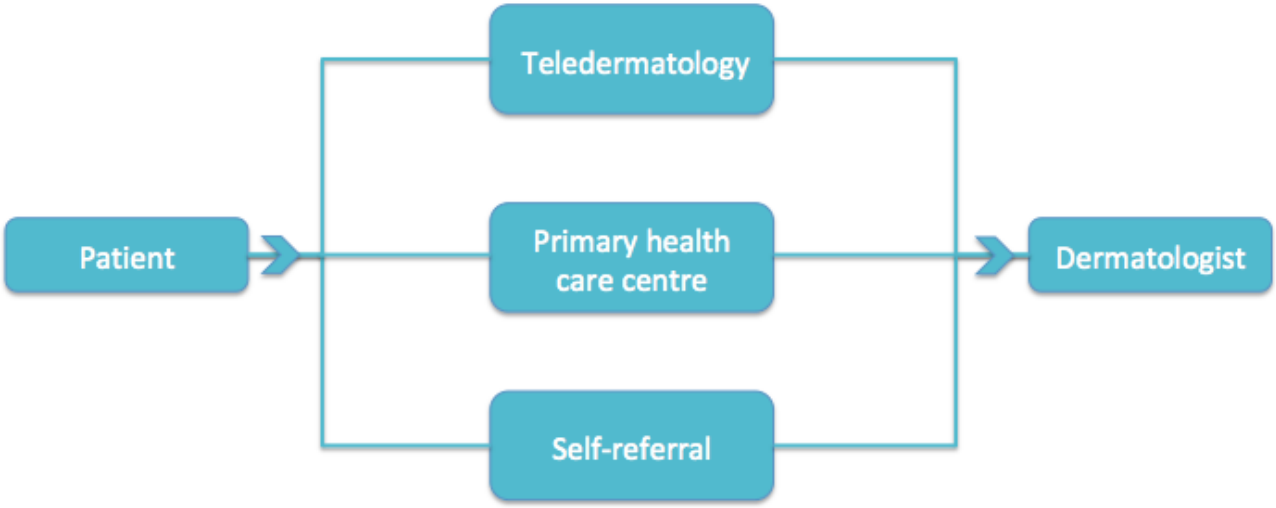

Figure 1 Flow chart of the current pathways for a patient to receive an appointment with a dermatologist

Teledermatology

Teledermatology is the practice of dermatology telemedicine, which can be defined as exchange of medical information through technologies over a distance on skin concerns. Historically records of telemedicine can be tracked 100 years back when Wilhelm Einthoven transmitted information of electrocardiograms and encephalograms through an analogue telephone network in 1910. In 1920 seafarers had developed a medical advice service based on Morse code and voice radio (9).

Dermatologic information could benefit from such technology, as anamnestic information is a major factor to determine diagnosis. Although the dermatology specialty relies heavily on visual information as well, meaning pictures would need to be included. Murphy et al.

conducted one of the first trials of dermatologic information exchanged through distance in 1972, which then compared the accuracy between direct examination and examination through television with up 89% correct accuracy through the latter mentioned (10). In 1997 Zelickson and Homan conducted a study in a nursing home including 29 residents with a total of 30 dermatologic skin conditions. It was investigated if up to three dermatologists could come up with the correct diagnosis and treatment plan of the pictures and information provided. With a combination of both picture and history, the physicians were able to diagnose 88% of the cases correctly and give the right treatment 90% of the cases (11). In 2002 Whited et al. investigated if a TD system would benefit waiting times compared to a traditional referral system. In this randomized trial it was found that the TD system resulted in significantly shorter waiting times with median in days being 42 vs. 127 in the traditional group ($p<0.001$). From the same trial it was found out that unnecessary visits could be prevented in the TD group, in the group using the traditional method no unnecessary visits could be prevented ($p<0.001$) (12).

A systematic review of 78 TD studies by Warshaw et al. was published in 2011 and several conclusions were made. Both store and forward (SAF) and live interactive TD were worse than Face-to-face (FTF)-visit regarding the diagnostic accuracy, although these methods were acceptable (FTF-visits were 5 to 19% better than TD, average absolute difference). In SAF-TD pictures are taken and sent for evaluation in any given time. With live interaction TD the consultation is rather done with the physician in one end and the patient in the other, traditionally through a videoconference. However the diagnostic accuracy was significantly lower for malignant lesions including squamous cell carcinoma, basal cell carcinoma and melanoma. FTF-visits could be avoided potentially with the TD and time to treat in days was significantly lower with TD. Patient satisfaction was seen as relatively high. Although not

enough information on clinical outcomes using TD were obtained, this is especially important for conditions with potential lethal outcomes. (13).

Mobile teledermatology

Smart phones have developed rapidly in the last decade, especially built in cameras that are capable of taking pictures of very good quality. Mobile telephone networks have developed as well and accessibility to Internet is easily attained through 3G or 4G (Third and fourth generation of wireless telecommunications technology). Naturally mobile TD developed. In one study of mobile TD average diagnostic concordance reached 70% with cellular phones (14). This study was made in 2005 on older phones that had worse image quality compared to todays standard. Looking at a study made in 2015 by Nami et al. diagnostic concordance reached 91.05% and overall therapy 79.80% (15). Börve et al. conducted a study on a multimedia message service (MMS)-referral method where dermatologists correctly diagnosed 78% of the patients. This study included 40 patients, 32 of which were diagnosed with cutaneous tumors (16).

Dermoscopes are used widely in dermatology and have been proven to be specially important in diagnosing malignant pigmented lesions (17). This tool consists of a magnifying plate and a polarized light source, which allows the user to see deeper structures of the skin. Such a tool can be combined with cellular phones for improved pictures, and when such pictures are included in the consultation it is known as mobile teledermoscopy (TDS). When these types of pictures are included in the consultation Ferrandiz et al. reached sensitivity of 92.86% and specificity of 96.24%. With regular TD sensitivity reached 86,57% and specificity 72.33% (18). Using TDS May et al. concluded that such a method could work as a tool for prioritizing patients to reduce waiting times, as did Borve et al. (19, 20).

Healthcare costs

There are some studies made on economic viability of a TD system, as Pak et al. concluded that SAF-TD was a cost saving strategy compared to a traditional consultation method (21). Eminovic et al. found out that cost savings could be made if users of a TD-system were living further than 75 km from the selected clinic (22). This is especially important in Sweden, as many people do not have access to specialist health care as easily depending on the region.

Material and methods

Teledermatology platform group

During 2017 from the 1 January until the 1 October, 766 people have used First Derm (iDoc 24 ®), a mobile teledermatology platform available to download (Apple store, Google store or used through their Internet webpage). The main goal of this service is to provide the user with a preliminary diagnosis and further instructions based on this. Unnecessary visits to dermatologists and PHC's can be prevented doing this.

How the teledermatology application (TDA) essentially works is the user taking two pictures of the lesion and providing a description of the lesion. The pictures were taken in two ways, one close to the lesion, 10 cm away, and one picture further away approximately 20 cm. If the user had access to an external dermoscope this could be attached on the phone for a TDS picture. The description included type of lesion (Nevus or other types), duration, and an opportunity for the user to describe the lesion with their own words. Personal information (age, sex, city and country) was requested as well.

A dermatologist assessed the information provided with the user remaining anonymous. Within 24 hours the user was answered and provided with an eight-digit code to view this case online. Prices start from 319 SEK for an answer within 24 hours. The user had an option to pay more for a faster answer (499 SEK, 8 hours).

This response could be a preliminary diagnosis of a potentially malignant lesion where the user was provided with further instructions and a recommendation to send a self-referral through the TDA. Another response of a less threatening issue the user was provided with exact instructions, for example to obtain a class I topical steroid to be applied to the concern with specific instructions of the frequency and application.

Out of the 766 users, 158 were recommended to self-treat; instructions were included. Several users (49) were in need of medical assessment, however not specifically by dermatologists. Out of these 44 were recommended to see a primary care physician, five were recommended to see a physician specialized in sexually transmitted infections (STI-physician). Users with benign lesions (297) were informed about the condition and such lesions did not require medical attention. However these users were instructed to check these lesions for any sort of change (growth, color change, bleeding etc.). Lesions considered benign included seborrheic keratosis, benign nevi for example.

The remaining users (262) were recommended to see a dermatologist and to send a tele-dermatology-referral (TDR) through the TDA (37 Swedish clinics in total have received these type of referrals). Only 105 users sent a TDR, these were included in the study. No information could be obtained on the other users. The TDA was used of their initiative. In table 1 all the users have been summarized with specific recommendations.

Table 1 Specific recommendations provided to users by dermatologists of the TDA in amount. All specified into date of usage of the TDA and the total period.

Date (day/month)	**Dermatologist**	**Primary care physician**	**STI-physician**	**Self-treatment**	**Benign lesions**	**Total (within period)**
1/1 - 1/3	38	10	0	24	36	108
1/3 - 1/5	40	4	2	31	41	118
1/5 - 1/7	95	12	0	48	121	276
1/7 - 1/9	72	15	2	37	84	210
1/9 - 1/10	17	3	1	18	15	54
1/1 – 1/10 (all)	262	44	5	158	297	766

Groups for comparison

For comparison 120 PHC-referrals and 120 regular self-referrals received at Sahlgrenska University Hospital (SUH) were obtained. There were no inclusion criteria for the different type of referrals. The PHC-referrals were obtained based on the visit to SUH, with the first visit 2 January 2017, until an amount of 120 was reached. The regular self-referrals were obtained based on the date of assessment until an amount of 120 was reached.

Table 2 Diagnosis distribution. Diagnoses only found in the self-referrals group are lesions described by patients.

Diagnosis	**PHC-referral**	**Self-referral**	**TDR**
Total	120	120	105
Skin change	21	38	0
Atypical nevus	0	0	29
Rash	4	18	0
Basal cell carcinoma	11	3	25
Suspicious nevus	9	9	0
Malignant melanoma	8	0	14
Psoriasis	8	7	0
Squamous cell carcinoma	8	1	0
Actinic keratosis	6	1	8
Acne	5	4	1
Eczema	5	5	0
Cutaneous horn	5	2	0
Suspicious wound	3	5	0
Atopic eczema	2	0	1
Pyogenic granuloma	2	0	1
Suspicion of malignancy	2	0	0
Seborrheic keratosis	1	0	5
Condyloma acuminatum	0	1	3
Seborrheic dermatitis	0	1	3
Dermatitis	1	0	3

Intradermal nevus	1	0	2
Lentigo	1	0	1
Abscess	1	0	0
Alopecia	1	0	0
Alopecia areata	1	0	0
Birt-Hogg-Dubés syndrome - Laser treatment	1	0	0
Chronic urticaria	1	0	0
Extended excision of SCC	1	0	0
Verruca plantaris	1	0	0
Full body examination, post-surgery malignant melanoma	1	0	0
Lichen planus	1	0	0
Lichen sclerosus et atrophicus	1	0	0
Heredity of malignant lesions	1	0	0
Mastocytosis	1	0	0
Nevus sebaceus	1	0	0
Onychomycosis	1	0	0
Osteogenesis imperfecta	1	0	0
Rosacea	1	3	0
Vitiligo	1	0	0
Dermatofibroma	0	0	1
Folliculitis	0	0	1
Giant cell tumour	0	0	1
Insect bite	0	0	1
MB Paget	0	0	1
Necrobiosis lipodica	0	0	1
Perioral dermatitis	0	1	1
Phototoxic reaction	0	0	1
Tinea corporis	0	0	1
Atypical hairiness	0	1	0
Bald spots	0	1	0
Cartilage formations	0	1	0
Dryness	0	1	0
Fungal infection	0	1	0
Genital infection	0	1	0
Hair loss	0	1	0
Hyperhidrosis	0	2	0
Pigmented nevus	0	1	0
Pigmented spots	0	2	0
Palmoplantar pustolosis (PPP)	0	2	0

Scabies	0	2	0
Scalp lesion	0	1	0
Scar	0	1	0
Skin change ("bubbles" described by patient)	0	1	0
Wart	0	2	0

Table 3 Age distribution

	Median (years)	**Mean (years)**	**Max (years)**	**Min (years)**
TDR	44,5	46,3	73	13
PHC-referral	51,9	53	94	1
Self-referral	46,5	46	87	8

Table 4 Gender distribution. In the TDR-group one user failed to mention gender

	Male	**Female**	**Missing**
TDR	52	52	1
PHC-referral	70	50	0
Self-referral	66	54	0

Followed up data

Further data was collected on the patients who had visited the clinic. This data included final diagnosis, date of visit, performed procedure (Biopsy, dermoscopy, excision) and date of procedure. The histopathological report was also collected. Waiting times in the whole country depended on a system of priority, which was based on the severity of the problem. In SUH this system was based on weeks with the highest priority being 0-1 week; these patients

were scheduled for an appointment within seven days. The lowest priority for an appointment was 1-3 month's assessment; actinic keratosis was issued with this assessment for example. Rejected referrals (non-prioritized/0-assessment) did not receive an appointment, but were instead instructed to seek care first-hand at a PHC.

Statistical analyses

The distribution of assessments/priorities was analyzed with Fischer's exact test because of the small sample followed up in the TDR-group. The TDR-group was compared with the regular self-referral group, as these referrals were the only ones rejected. All three groups (TDR, PHC-referrals and regular self-referrals) were compared with the rejected referrals excluded from the analysis.

Days waited were analyzed with Kruskal-Wallis test with all three groups included as the days were not distributed evenly. The groups were separated into sub groups based on assessment and diagnosis, to see if there was any difference. The TDR-group was compared separately to the other two groups with Mann-Whitney U test to determine if the difference in waiting time would remain statistically significant. This test was used, as data was not evenly distributed.

In previous studies times to treat in days could be shortened because of included pictures in the TD consultation method enabling a plan to treat already at received referral (12, 19). Lesions in need of excision were treated surgically on the first visit in all groups; there were only three cases in total (one in the TDR- group, two in the PHC-group) that received treatment after the first visit. Because of this no further analysis was made.

Ethical considerations

No ethical permit was obtained as this report would not be published and is considered a student degree project thus covered by the law (SFS 2003:460 2§) (23). Based on this all hospitals were initially contacted formally, requesting journals connected to the TDR. However all clinics required patient consent. All included users were contacted formally, requesting consent to take part of journals connected to the TDR.

From the initial contact with hospitals, Karolinska University hospital (KUH) and Norrlands University hospital (NUH) had informed that self-referrals were not accepted. Patients that sent TDR's to KUH were instead instructed to seek care at private dermatology clinics in Stockholm. An agreement had been made between these clinics and the Swedish healthcare system to take care of such referrals. These patients were contacted and asked where they had received care instead. NUH instructed such patients to seek care at PHC's first-hand; these users were contacted similarly to those of KUH.

SUH had the highest amount of TDR's, with 30 users in total. To access these journals a specific permit was obtained and approved by the head of dermatology (verksamhetschef). The same permit was obtained to gain access to the 120 PHC- and 120 regular self-referrals. Nine of the TDR's were rejected and were contacted as those of KUH and NUH.

Results

Exclusions

In the TDR-group 54 referrals were excluded, as these could not be followed up. Out of these one user declined consent, one clinic reported no information of such a referral, 47 failed to give consent in time. The patient that had sent the referral to the clinic without any information could not be contacted. Of the remaining five from the excluded referrals, two users provided the wrong address thus no contact could be made. Consent was obtained from three more users, however the clinic failed to send any journals. This clinic was contacted several times but informed that no requests had been received.

KUH and NUH informed that self-referrals were not accepted, thus six more TDR's considered rejected were included.

Table 5 Followed up TDR's with amount of visits, distribution of malignant and benign lesions. Actinic keratosis, BCC, malignant melanoma was considered malignant lesions. Amount of days waited in mean value, 'N' meant no visit of any patients. Numbers within brackets are amount of visits of the specific type of lesion.

Hospital	Amount	Visits	Malignant	Benign	Mean wait time (days)
Sörmland hospital	1	0	0	1	N
KUH	4	0	0	4	N
NUH	2	0	1	1	N
HudDoktorn, Örebro	1	1	1	0	77
DCH, Stockholm	1	1	0	1	63
Ryhov County hospital	2	2	1	1	60,5
Uddevalla hospital	5	4	4 (3)	1	59
SUH	29	14	15 (7)	14 (7)	58,6
DCH, Malmö	3	3	1	2	45
Visby hospital	1	1	0	1	33
Södersjukhuset	1	1	0	1	28

Södra Älvsborgs sjukhus	1	1	1	0	25
Kungsholmens dermatology clinic	2	2	0	2	21
Kalmar hospital	1	1	1	0	16
Växsjö hospital	1	1	1	0	15
Falun hospital	1	1	0	1	13

Table 6 Rejected TDR's with diagnosis and which hospital rejected the referral.

Hospital	**Diagnosis**
SUH	Atypical nevus
SUH	Atypical nevus
SUH	Basal cell carcinoma
SUH	Basal cell carcinoma
SUH	Condyloma acuminatum
SUH	Condyloma acuminatum
SUH	Seborrheic keratosis
SUH	Tinea corporis
Mälarsjukhuset	Necrobiosis lipoidica
KUH	Pyogenic granuloma
KUH	Perioral dermatitis
KUH	Seborrheic keratosis
KUH	Atypical nevus
NUH	Basal cell carcinoma
NUH	Mb Paget

No referrals from the other two groups were excluded as information such as assessment could be obtained. The TDR-group diagnoses with excluded referrals and referrals with assessments are displayed below (table 9). As no referrals were excluded from the other groups they remained unchanged.

Table 7 Age distribution after exclusions, and TDR's with assessments

	Median (years)	Mean (years)	Max (years)	Min (years)
TDR (Excluded)	44,5	46,4	72	13
TDR (Assessments)	45	47	72	13
PHC	51,9	53	94	1
Self-referral	46,5	46	87	8

Table 8 Gender distribution after exclusions, and TDR's with assessments

	Male	Female	Total
TDR (Excluded)	30	29	59
TDR (Assessments)	18	12	30
PHC	70	50	120
Self-referral	66	54	120

Table 9 Diagnosis distribution. TDR (included) are followed up referrals, TDR (assessment) are those from SUH. Diagnoses only found in the self-referrals group are lesions described by patients.

Diagnosis	PHC-referrals	Self-referrals	TDR (included)	TDR (assessments)
Total	120	120	59	30
Skin change	21	38	0	0
Basal cell carcinoma	11	3	16	9
Atypical nevus	0	0	18	10
Suspicious nevus	9	9	0	0
Malignant melanoma	8	0	8	6
Condyloma acuminatum	0	1	2	2
Psoriasis	8	7	0	0
Squamous cell carcinoma	8	1	0	0
Actinic keratosis	6	1	3	0
Acne	5	4	0	0

Eczema	5	5	0	0
Cutaneous horn	5	2	0	0
Rash	4	18	0	0
Suspicious wound	3	5	0	0
Pyogenic granuloma	2	0	1	0
Atopic eczema	2	0	0	0
Suspision of malignancy	2	0	0	0
Seborrheic keratosis	1	0	2	1
Dermatitis	1	0	1	0
Intradermal nevus	1	0	1	0
Lentigo	1	0	1	1
Abscess	1	0	0	0
Alopecia	1	0	0	0
Alopecia areata	1	0	0	0
Birt-Hogg-Dubés syndrome - Laser treatment	1	0	0	0
Chronic urticaria	1	0	0	0
Extended excision of SCC	1	0	0	0
Verruca plantaris	1	0	0	0
Full body examination, post-surgery Malignant melanoma	1	0	0	0
Lichen planus	1	0	0	0
Lichen sclerosus et atrophicus	1	0	0	0
Heredity of malignant lesions	1	0	0	0
Mastocytosis	1	0	0	0
Naevus sebaceus	1	0	0	0
Onychomycosis	1	0	0	0
Osteogenesis imperfecta	1	0	0	0
Rosacea	1	3	0	0
Vitiligo	1	0	0	0
Giant cell tumour	0	0	1	0
MB Paget	0	0	1	0
Necrobiosis lipodica	0	0	1	0
Perioral dermatitis	0	1	1	0
Seborrheic dermatitis	0	1	1	0
Tinea corporis	0	0	1	1
Atypical hairiness	0	1	0	0
Bald spots	0	1	0	0

Cartilage formations	0	1	0	0
Dryness	0	1	0	0
Fungus infection	0	1	0	0
Genital infection	0	1	0	0
Hair loss	0	1	0	0
Hyperhidrosis	0	2	0	0
Pigmented nevus	0	1	0	0
Pigmented spots	0	2	0	0
Palmoplantar pustolosis (PPP)	0	2	0	0
Scabies	0	2	0	0
Scalp lesion	0	1	0	0
Scar	0	1	0	0
Skin change ("bubbles" described by patiet)	0	1	0	0
Wart	0	2	0	0

Assessment

A difference in distribution of priorities was observed between all groups compared. With all priorities, the PHC-referrals were excluded from the first analysis as these could not be rejected or non-prioritized, thus only TDR's and regular self-referrals were included for this part. The difference in distribution of assessments was statistically significant (p=0.000013, Fischer's exact test), however there were priorities in these groups that could only be found in one another. These included one 0-1 prioritized referral in the TDR-group, one 0-2 prioritized in the self-referral group and two of which were not prioritized at all in the self-referral group. With these referrals excluded the difference remained statistically significant (p=0.000009, Fischer's exact test. Figure 2, table 10).

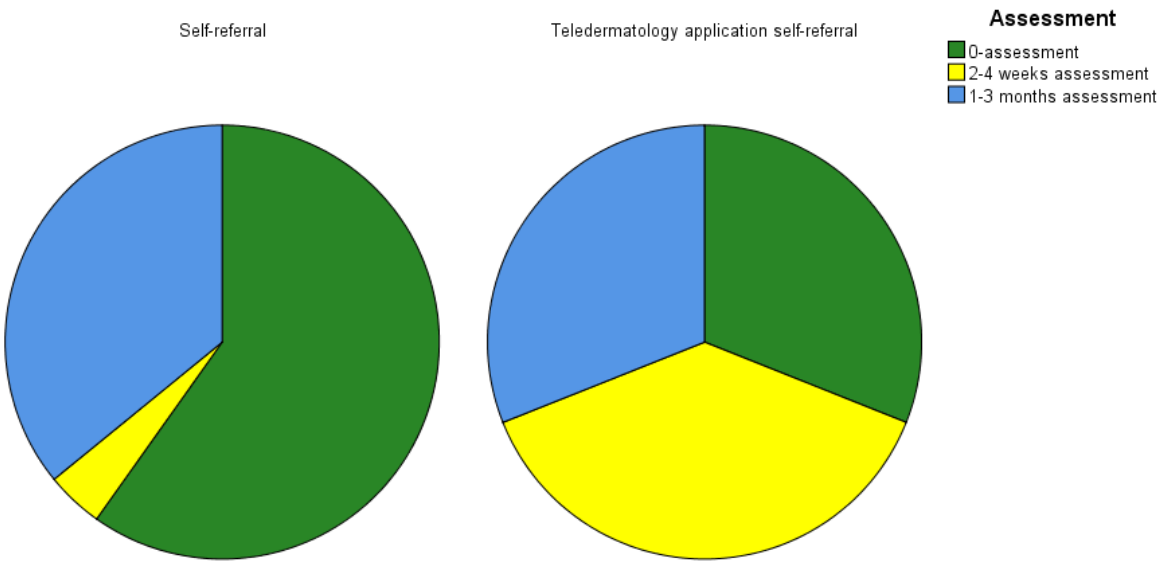

Figure 2 Distribution of assessments of the referrals, comparing regular self-referrals and TDR's in percentage. 0-assessment is the same as rejected. 0-1 week-, 0-2 weeks assessed referrals are excluded and referrals with missing information are excluded.

Table 10 Assessments of referrals specified in amounts and percentage of each group, 0-1 week-, 0-2 weeks-assessed referrals have been excluded and referrals without any assessments as well.

			Self-referral	TDR	Total
Assessment	Rejected referral	Count	70	9	79
		% within Type	59,8%	31,0%	54,1%
	2-4 weeks assessment	Count	5	11	16
		% within Type	4,3%	37,9%	11,0%
	1-3 months assessment	Count	42	9	51
		% within Type	35,9%	31,0%	34,9%
Total		Count	117	29	146
		% within Type	100,0%	100,0%	100,0%

For the second analysis the PHC-referrals were included as well and referrals that were rejected were excluded completely. Similarly to the previous analysis the difference was statistically significant (p=0.002, Fischer's exact test) and as in previous analysis there were referrals with priorities that could on be found in one group. These referrals were those mentioned previously and three additional 0-1 week prioritized referrals, two 0-2 weeks referrals and one more referral missing information. These were excluded. Although the difference remained statistically significant in this analysis (p=0.000335, Fischer's exact test. Figure 3, table 11).

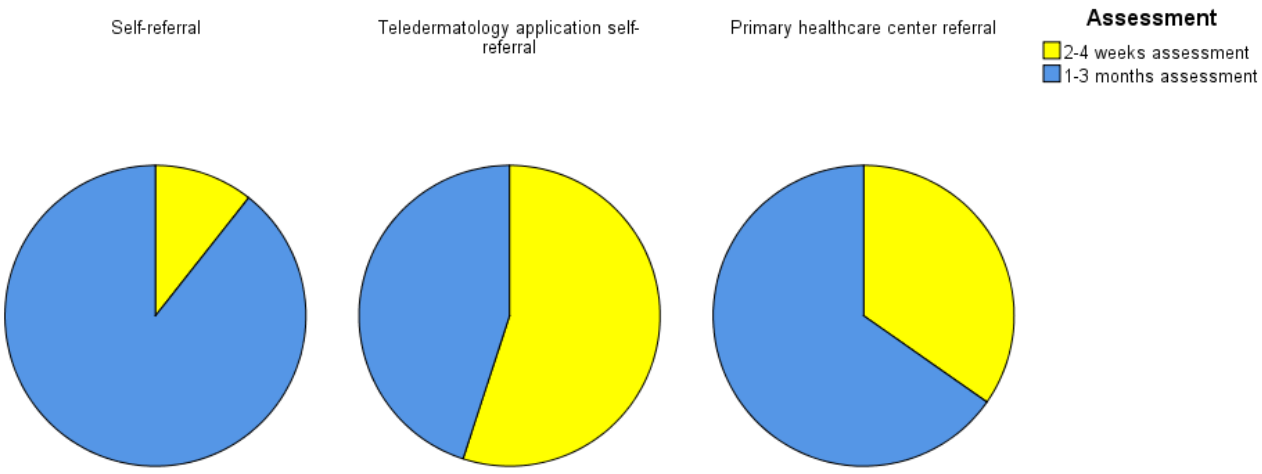

Figure 3 Distribution of assessments in percentage. Comparing all types of referrals. Rejected referrals are excluded from this pie chart. Referrals assessed as 0-1 week, 0-2 weeks have been excluded, and referrals missing information have been excluded as well.

Table 11 Assessments of referrals specified in amounts and percentage of each group. Rejected referrals are excluded from this table. 0-1 week-, 0-2 weeks-assessed referrals have been excluded and referrals without any assessment as well.

			Self-referral	TDR	PHC-referral	Total
Assessment	2-4 weeks assessment	Count	5	11	25	41
		% within Type	10,6%	55,0%	34,7%	29,5%
	1-3 months assessment	Count	42	9	47	98
		% within Type	89,4%	45,0%	65,3%	70,5%
Total		Count	47	20	72	139
		% within Type	100,0%	100,0%	100,0%	100,0%

Waiting times

An analysis to compare the waiting times between all types of referrals depending on the priority set. The priorities that were analyzed were 1-3 months-, 2-4 weeks- and 0-1 weeks prioritized referrals as at least on such referral could be found in two or more groups. In the referrals prioritized 1-3 months and 2-4 weeks the difference was statistically significant between all three groups, however this does not imply lower waiting times in any type of referral. Thus an analysis comparing the TDR's separately to the other types of referral was made. A Mann-Whitney U test indicated that days waited for referrals prioritized as 2-4 weeks were significantly lower for TDR's compared to PHC-referrals (p=0.001, Mann-Whitney U test, Fig 4, table 12).

Table 12 Amount of days waited, in all groups of referrals assessed 2-4 weeks.

	Median (days)	**Mean (days)**
TDR	31	31.4
PHC	44	53.6
Self-referral	26	25.8

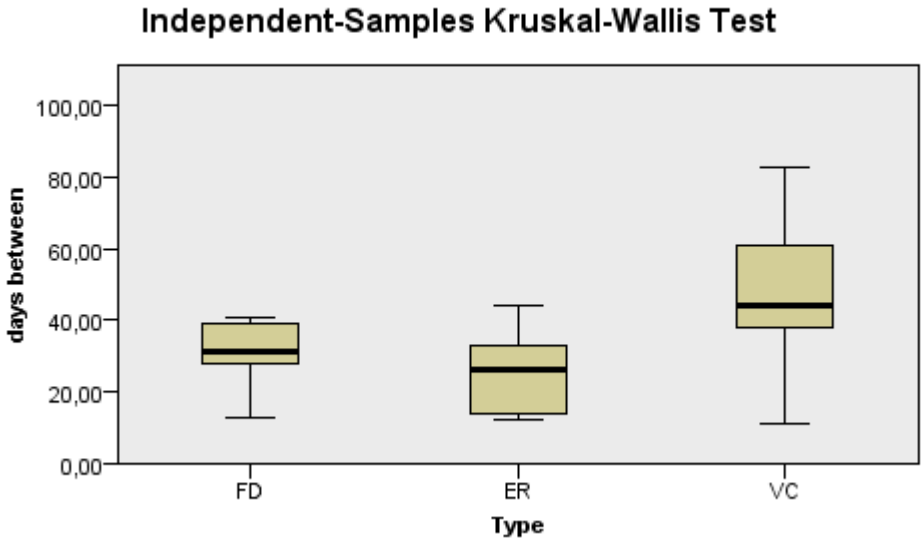

Figure 4 Boxplot comparing the waiting times in days in all three groups assessed as 2-4 weeks priority with outliers excluded. Thicker black lines towards the centre are the median values (table 12.) FD = TDR, ER = Self-referrals and VC=PHC-referrals.

Although none of the other variations (2-4 weeks, 1-3 months) were statistically significant.

Referrals prioritized as 0-1 weeks were only found in the TDR-group and the PHC-group and the difference in days waited were not statistically significant (p=0.546, Kruskal-Wallis test).

The same analyses were made based on the preliminary diagnosis on the waiting times with malignant melanoma, basal cell carcinoma, and actinic keratosis included. Although waiting times were lower for TDR's and regular self-referrals, none of these results were statistically significant as the sample size was small, thus no further analyses were made on this data.

Time to treat, waiting time – Diagnosis specific

Malignant melanoma – First-time visit

Only referrals from the TDR- and PHC-group were diagnosed with malignant melanoma. The difference in days waited of referrals diagnosed as malignant melanoma was not statistically significant between TDR and PHC-referrals (p=0.236, Kruskal-Wallis test).

In total there were 19 with this diagnosis who had visited a dermatologist, seven from the TDR group and 12 from the PHC-group. The median value in days in the TDR-group was 20 days and 39.5 days for the PHC-group. The mean values were 18.7 days for the TDR-group and 33.2 days for PHC-group.

Of the users with malignant melanoma in the TDR-group, five sent referrals to SUH where the mean waiting time in days was 24.4. The remaining two visited the county hospital in Kalmar with a waiting time of 16 days, and the Central hospital in Växsjö with a waiting time of 15 days.

In the TDR-group two of the users required surgical intervention as the other five were assessed as benign lesions. Both users had the lesion surgically excised, with one patient treated the first day of visit and the other one eight days after. Both lesions were histopathologically confirmed as malignant melanoma (MM) in situ. There was a TDR

prioritized as 2-4 weeks, however this period had been exceeded and no information was available if the patient had cancelled or rescheduled the appointment.

In the PHC-group four patients received treatment as the remaining eight were assessed as benign lesions. These patients were treated surgically, with two patients treated on the first day of visit, one the day after, and the remaining patient treated nine days after the first visit. Of all these lesions only one was confirmed histopathologically as MM in situ. The remaining lesions were reported as benign nevi and BCC.

Atypical nevus

There were 13 users in total followed up diagnosed with atypical nevus, no referrals with this diagnosis was found in the other groups. Out of these seven had visited SUH, with a mean waiting time of 44.6 days. The remaining users had visited different hospitals (Table 16). SUH rejected two referrals diagnosed with atypical nevus, and one referral was assessed, as 1-3 month's priority however this patient had not yet visited the clinic.

Table 13 Amount of days waited of referrals diagnosed with atypical nevus for specific hospitals.

Waiting time (days)	**Hospital**
63	Diagnostiskt Centrum Hud, Stockholm
37	Ryhov County hospital
33	Visby hospital
28	Södersjukhuset
25	Uddevalla hospital
13	Falun hospital

Discussion

Design of study

The amount of followed up TDR's were low compared to those of the other groups, especially assessed referrals as these were limited to SUH. The time factor was one of the reasons for this as 47 patients failed to send consent in time. Journals were not sent in time from one clinic as well

In a future study of similar design followed up referrals could potentially be limited to one hospital or a single region in Sweden. There are different systems in the country regarding the type of referrals accepted. The TDR's followed up in this study were considered the same as regular self-referrals even though all of these had been assessed by a dermatologist. This was an issue in larger hospitals such as NUH and KUH as self-referrals were not accepted in general. Although in Stockholm an agreement between private dermatology clinics and the Swedish healthcare system had been reached. This meant that referrals of this type were accepted with no additional cost for the patient as it was funded by the Swedish healthcare system.

The difference in time was another issue of this study. The TDR's were all from 2017, however referrals from the other groups were primarily from 2016. In this period the majority of the patients waited longer than three months, this number has improved in 2017. This is described in detail in the next headline.

All groups were different regarding diagnoses and age distribution. Patients without general knowledge of dermatologic conditions wrote regular self-referrals. Lesions were described based on looks, for example as a "skin change that is red" but never as atypical nevus unless

the patient had experienced a similar lesion before. The TDR's and PHC-referrals were diagnosed similarly though. In both the PHC-group and regular self-referral group the patients were generally older. Older patients could potentially benefit using a TD-system as amount of visits could be decreased and even avoided. Generally all groups had a higher amount of male patients.

Waiting times and treatment

Users of TDR's and regular self-referrals had the shortest waiting times of all assessments compared, previous studies reported similar results however these were analysed differently (12, 19). Although days waited were only significantly lower for the TDR-group compared to the PHC-group in referrals prioritized as 2-4 weeks.

However the majority of referrals from the PHC-group were from 2016, which was before SUH had implemented healthcare guarantee (Vårdgaranti) (24). This meant guaranteed visits to dermatologists within three months. This could also explain the difference in days waited even though the referrals had been prioritized similarly.

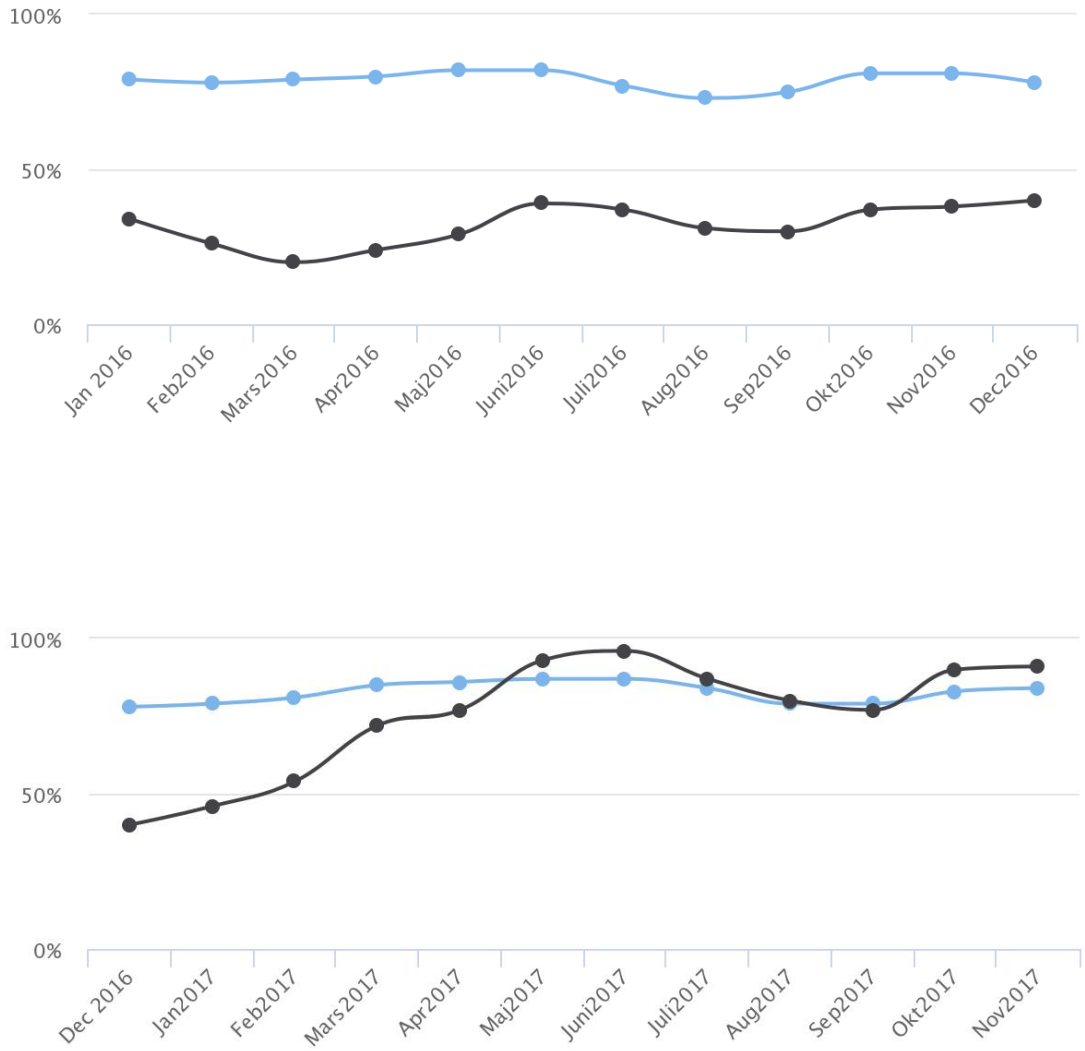

Figure 5 (a, b) Percentage of patients visiting a dermatologist within three months in whole of Sweden and the western region compared, January 2016 – November 2017. The blue line represents the whole country. The black line represents the western region of Sweden. Source: http://www.vantetider.se/Kontaktkort/Vastra-Gotalands/SpecialiseradBesok [Last accessed 2 February 2018]

The shortest waiting times were observed in the regular self-referral group, although the majority of these referrals were also rejected. Only two patients with malignant lesions (actinic keratosis, BCC) received an appointment using regular self-referrals because of previous history of similar lesions. An explanation for the lower waiting times could be that

referrals accepted in this group were considered especially in need of treatment, as a sufficient description was provided by the patient.

In the self-referral group it was observed that eight rejected referrals had received an appointment, although this was with PHC-referrals. All rejected referrals were instructed to seek care at a PHC as previously mentioned. Patients of rejected referrals were contacted with traditional post, phone call or a referral response.

Generally all patients in the all groups received treatment on the first visit. However there were exceptions in the TDR-group and PHC-group. All these patients were diagnosed with malignant melanoma and were treated surgically with no complications.

Costs

No analysis was made regarding cost savings in this study. Many users of the TDA were from smaller regions of Sweden, and as stated by Eminovic et al. patients living further than 75 km from selected clinic could benefit the Swedish healthcare system economically (22). Although no analysis of this was made but should be looked into as previous results suggests economic savings.

Risks

As stated by Warshaw et al. diagnostic accuracy was significantly lower using TD for malignant lesions (13). Only users that sent self-referrals through the TDA were followed up, furthermore exclusions were made. None of the excluded users were followed up and neither any of the other recommendations. A potential risk is missing a potential malignant lesion with lethal outcomes. However no analysis of this had been made.

Regional differences - TDR

Hospitals such as KUH and NUH did not accept the TDR's as these were considered the same as regular self-referrals. As mentioned previously an agreement had been made with private dermatology clinics in Stockholm to take care of self-referrals. NUH instructed everyone with self-referrals to seek care at PHC's first-hand. Of these rejected referrals there was only one malignant lesion (BCC). This user was contacted but did not follow the instructions provided by the hospital (NUH).

Referrals issued as malignant melanoma had lower waiting times in smaller hospitals compared to SUH. For the smaller hospitals it took 15 and 16 days respectively, while the mean waiting time in days was 24.4 for SUH.

Referrals issued as atypical nevus were accepted in all clinics except SUH where two out of ten were rejected. The remaining referrals were assessed differently. Waiting times of this diagnosis varied between all clinics.

SUH potentially have seven more visits as six of these referrals were prioritized as 1-3 months and one as 2-4 weeks, the remaining referrals were rejected. The referral prioritized as 2-4 weeks was issued as malignant melanoma and had exceeded the waiting time. No information could be obtained of the current status. Of the referrals prioritized 1-3 months, four of these were issued as BCC, one as atypical nevus, and the remaining one as atopic eczema. The rejected referrals with specific diagnoses are listed in table 6.

In Uddevalla hospital no information at all could be found on one patient. Johannesberg PHC in Härnösand informed that no TDR had been received. In Östergötland one patient had cancelled the appointment, because the lesions had resolved.

Generally referrals issued with malignant diagnoses received an appointment in all clinics except NUH, however several benign lesions in need of assessment by a dermatologist were rejected. Clinics such as KUH and NUH did not accept self-referrals. A possible explanation of this may be that these clinics were overwhelmed by PHC-referrals and accepting several types would be impossible.

The waiting times varied between smaller and larger clinics. For example in Stockholm, Kungsholmens dermatology clinic had a mean waiting time of 21 days while it was 63 days in DCH, Stockholm. Smaller clinics such as HudDoktorn in Örebro had a waiting time of 77 days while it was only 13 days in Falun hospital. However all these were diagnosed differently thus it is hard to draw any conclusions.

The future of commercial TD

A large majority of patients that used regular self-referral and PHC-referrals could use the TDA for a first time visit to a dermatologist. Those in the regular self-referral group could benefit from the TDA as many of these patients were concerned about skin changes or suspicious nevi. All of these referrals of these concerns were rejected in this group, although in the TDR-group the majority of referrals issued as suspicious pigmented lesions were followed up. In the PHC-group there were referrals issued with post-surgery full body examination, these could potentially benefit from using a TDA, however this would require the user to provide sufficient information. Although there would be a notable variation in

description evidently seen in the regular self-referrals and also the TDA descriptions, with some users providing detailed descriptions and some rather lacking information.

TD has risks as well, as concluded by Warshaw et al. malignant lesions were significantly lower regarding diagnostic accuracy (13). There were also users that provided descriptions lacking information. Pictures provided by the users varied in quality, although if the quality was not sufficient the user was instructed to send new pictures with no extra costs. These potentially affect the outcome negatively, such as providing the user with the wrong preliminary diagnosis thus missing a potential malignant lesion.

For continuous usage of a commercial TDA the risks have to be considered. Although in the TDR-group several patients received appointments directly, thus unnecessary visits could be skipped. Several of the users of the TDA were also instructed to self-treat or simple wait and observe. These actions are both economically viable and also relieve pressure on the Swedish healthcare system, however no analysis of this has been made.

Mobile TD has been recently introduced into a commercial form, which is why results in this study are varied. For the upcoming years mobile TD may develop similarly to TD and regular mobile TD, as smart phones are constantly developing and the general public learning about dermatologic lesions. TDA's such as the one analysed in this study may develop regarding the accessibility for the users as the applications itself is developing. However these are only speculations based on previous studies and results collected in this study.

Conclusion

Based on results from this study it is hard to draw any conclusions, as the sample analysed was small. A statistical significant in distribution of assessments was seen between all groups. The TDR-group had higher amount high-prioritized referrals in percentage than the other groups. The percentage of rejected referrals was also lower than regular self-referrals.

Generally the waiting times were shorter for both TDR's and self-referrals than PHC-referrals. Regular self-referrals had the shortest waiting times based on assessment, however these were rejected the most as well. TDR's had slightly longer waiting times than regular self-referral with less rejected referrals in percentage. Although waiting times were only significantly lower between TDR-group and PHC-group in referrals prioritized as 2-4 weeks.

For future studies we recommend further collection of data regarding TDR's.

Populärvetenskaplig sammanfattning

Hudcancer är bland de snabbast ökande cancertyperna i Sverige sett ur Socialstyrelsens data på cancerincidens, med hela 6% årlig ökning. Detta har medfört ökat tryck på hudkliniker runt om i landet. Med standardiserade vårdförlopp (SVF) har man kunnat förbättra situationen för malignt melanom samt skivepitelcancer, dock har generella dermatologiska åkommor långa väntetider fortfarande. Flera studier har de senaste årtionden gjorts på teledermatologi vilket har visat goda resultat för väntetider, behandling, samt onödiga besök som kunnat hindras och dessutom möjliggjort planering för patienter innan de ens besökt kliniken. Med utveckling av dagens teknologi har även en mobil form utvecklats, mobil teledermatologi som även visat goda resultat dock inte lika bra som den vanliga formen.

I denna studie har man följt upp 105 användare av en mobil teledermatologi tjänst som har blivit rekommenderade att söka specialistvård. Utifrån detta har de skickat en remiss till vald hudklinik. Målet är att undersöka om en sådan tjänst kan triagera patienterna rätt och även leda till snabbare besökstid hos en specialist. Man har även tagit fram 120 remisser skickade från vårdcentral, samt 120 egenremisser skickade av patienter till Sahlgrenska Universitetssjukhuset för att jämföra hur dessa har bedömts och hur lång tid dessa patienter har fått vänta.

Med samlad data var skillnaden signifikant gällande bedömningarna mellan de olika remisserna. Det var även signifikant skillnad i distribution av väntetiderna mellan de olika grupperna i 2-4 veckors bedömda remisser, samt 1-3 månaders bedömda remisser. Detta innebär dock enbart att det finns skillnad i väntetid mellan de tre gruppern. därför jämfördes teledermatologi-remisserna separat med de andra grupperna. Väntetiden var signifikant lägre jämfört med vårdcentralsremisser enbart för remisser med 2-4 veckors prioritet.

Samlad data antyder att andelen nekade remisser kan sänkas med mobil teledermatologi och samtidigt skicka in patienter i större behov av specialistvård baserat på andelen 2-4 veckors bedömda remisser. Patienter med egenremisser fick vård snabbast, dock var dessa mest benägna att få sin remiss nekad vilket teledermatologi-remissen hade lägre andel av. Patienter som använt sig av teledermatologi-tjänsten hade kortare väntetid än vårdcentralsremisserna. Vårdcentralsremisserna var dock från 2016, dessa hade i regel väldigt långa väntetider, men med införande av ett mål under 2017 på Sahlgrenska Universitetssjukhuset följer man i regel upp alla patienter inom bedömningen man fått. Under 2016 träffade färre än hälften av patienter en specialist inom 3 månader, detta nummer ligger på 79% November 2017. Dock är det svårt att dra en slutsats utifrån detta eftersom mängden egenremisser baserade på teledermatologi-tjänsten var begränsad. Vi rekommenderar ytterligare insamling av data för framtida studier.

References

1. Socialstyrelsen. Statistics on Cancer Incidence 2015 2015 [Available from: https://www.socialstyrelsen.se/Lists/Artikelkatalog/Attachments/20468/2017-1-20.pdf. [Last accessed 2 February 2018]
2. Gandini S, Sera F, Cattaruzza MS, Pasquini P, Zanetti R, Masini C, et al. Meta-analysis of risk factors for cutaneous melanoma: III. Family history, actinic damage and phenotypic factors. European Journal of Cancer. 2005;41(14):2040-59.
3. Armstrong BK, Kricker A. The epidemiology of UV induced skin cancer. Journal of Photochemistry and Photobiology B: Biology. 2001;63(1):8-18.
4. Ting W, Schultz K, Cac NN, Peterson M, Walling HW. Tanning bed exposure increases the risk of malignant melanoma. International Journal of Dermatology. 2007;46(12):1253-7.
5. Bränström R, Chang YM, Kasparian N, Affleck P, Tibben A, Aspinwall LG, et al. Melanoma risk factors, perceived threat and intentional tanning: An international online survey. European Journal of Cancer Prevention. 2010;19(3):216-26.
6. Socialstyrelsen. Standardiserade vårdförlopp i cancervården 2016 [Available from: http://www.socialstyrelsen.se/Lists/Artikelkatalog/Attachments/20397/2016-11-5.pdf. [Last accessed 2 February 2018]
7. Väntetider.se. Väntetider i Sverige 2017 [Available from: http://www.vantetider.se/Kontaktkort/Sveriges. [Last accessed 2 February 2018]
8. Väntetider.se. Väntetider i Västra Götalands regionen 2017 [Available from: http://www.vantetider.se/Kontaktkort/Vastra-Gotalands/SpecialiseradBesok/. [Last accessed 2 February 2018]
9. Stanberry B. Telemedicine: Barriers and opportunities in the 21st century. Journal of Internal Medicine. 2000;247(6):615-28.
10. Murphy RLH, Jr., Fitzpatrick TB, Haynes HA, Bird KT, Sheridan TB. Accuracy of Dermatologic Diagnosis by Television. Archives of Dermatology. 1972;105(6):833-5.
11. Zelickson BD, Homan L. Teledermatology in the nursing home. Archives of Dermatology. 1997;133(2):171-4.
12. Whited JD, Hall RP, Foy ME, Marbrey LE, Grambow SC, Dudley TK, et al. Teledermatology's impact on time to intervention among referrals to a dermatology consult service. Telemedicine journal and e-health : the official journal of the American Telemedicine Association. 2002;8(3):313-21.
13. Warshaw EM, Hillman YJ, Greer NL, Hagel EM, MacDonald R, Rutks IR, et al. Teledermatology for diagnosis and management of skin conditions: A systematic review. Journal of the American Academy of Dermatology. 2011;64(4):759-72.
14. Massone C, Lozzi GP, Wurm E, Hofmann-Wellenhof R, Schoellnast R, Zalaudek I, et al. Cellular phones in clinical teledermatology. Archives of Dermatology. 2005;141(10):1319-20.
15. Nami N, Massone C, Rubegni P, Cevenini G, Fimiani M, Hofmann-Wellenhof R. Concordance and Time Estimation of Store-and-Forward Mobile Teledermatology Compared to Classical Face-to-Face Consultation. Acta dermato-venereologica. 2015;95(1):35-9.
16. Börve A, Holst A, Gente-Lidholm A, Molina-Martinez R, Paoli J. Use of the mobile phone multimedia messaging service for teledermatology. Journal of Telemedicine and Telecare. 2012;18(5):292-6.
17. Vestergaard ME, Macaskill P, Holt PE, Menzies SW. Dermoscopy compared with naked eye examination for the diagnosis of primary melanoma: A meta-analysis of studies performed in a clinical setting. Br J Dermatol. 2008;159(3):669-76.

18. Ferrándiz L, Ojeda-Vila T, Corrales A, Martín-Gutiérrez FJ, Ruíz-de-Casas A, Galdeano R, et al. Internet-based skin cancer screening using clinical images alone or in conjunction with dermoscopic images: A randomized teledermoscopy trial. Journal of the American Academy of Dermatology. 2017;76(4):676-82.
19. May C, Giles L, Gupta G. Prospective observational comparative study assessing the role of store and forward teledermatology triage in skin cancer. Clinical and Experimental Dermatology. 2008;33(6):736-9.
20. Borve A, Terstappen K, Sandberg C, Paoli J. Mobile teledermoscopy-there's an app for that! Dermatology practical & conceptual. 2013;3(2):41-8.
21. Pak HS, Datta SK, Triplett CA, Lindquist JH, Grambow SC, Whited JD. Cost minimization analysis of a store-and-forward teledermatology consult system. Telemedicine and e-Health. 2009;15(2):160-5.
22. Eminović N, Dijkgraaf MG, Berghout RM, Prins AH, Bindels PJE, De Keizer NF. A cost minimisation analysis in teledermatology: Model-based approach. BMC Health Services Research. 2010;10.
23. Etikprövningsnämnden. SFS 2003:460 6 § [Available from: https://www.epn.se/start/faq/. [Last accessed 2 February 2018]
24. Vårdguiden. Vårdgaranti Västra Götalandsregionen [Available from: https://www.1177.se/Vastra-Gotaland/Regler-och-rattigheter/Vardgaranti-i-Vastra-Gotaland/. [Last accessed 2 February 2018]