Healthcare Improvement Scotland | SHTG Advice on health technologies

SHTG Assessment
February 2023

Store-and-forward teledermatology for triage of primary care referrals

What were we asked to look at?

We were asked by the Accelerated National Innovation Adoption (ANIA) collaborative and the Dermatology AI (artificial intelligence) Consortium to look at the evidence on the use of store-and-forward (SAF) teledermatology (TD) to triage referrals from primary care to secondary care dermatology.

Why is this important?

There is currently a backlog of referrals from primary care leading to significant waiting time for patients to access specialist dermatology services across Scotland. This has been exacerbated by the COVID-19 pandemic. National triage pathways could facilitate timely diagnosis and treatment for people with skin conditions, particularly important for people with skin cancers.

What was our approach?

We conducted a review of the evidence on the clinical effectiveness, cost effectiveness and safety of SAF TD for secondary care triage. More information about SHTG Assessments can be found on our website.

What next?

ANIA and the Dermatology AI Consortium will use our assessment to inform a value case and subsequent decision making on the secondary care use of TD triage of referrals from primary care. If approved, this approach will inform a national digital-enabled dermatology pathway across Scotland.

Key findings

- Six randomised controlled trials (RCTs) were identified. Most were of limited applicability to the Scottish healthcare context.
- Five comparative observational studies and three single arm studies were examined. These mainly focused on populations with lesions suspicious for skin cancer(s) rather than unselected primary care referral populations. One of these was in a paediatric population.
- Across the evidence base as a whole there was evidence that teledermatology for secondary care triage of referrals:
    - reduces the number of face-to-face secondary care appointments required. Where dermatology specialist triage provided advice or reassurance, published studies reported that in the region of 50% of referrals could be managed in primary care
    - facilitates more accurate allocation of referral priority
    - reduces waiting time for specialist dermatology input
    - reduces time to commencing treatment, and
    - offers similar clinical outcomes, quality of life and patient satisfaction as conventional referral.
- The estimated proportion of primary care referrals to secondary care dermatology services that currently include digital images ranges from 10-80% by health board.
- The following points limit the applicability of this evidence to the Scottish context.
    - dermatoscopic images formed part of the intervention in the majority of the studies where patients with suspicious lesions were included
    - most of the studies involved general practitioners (GPs) with training in photographing lesions and images were assessed by experienced teledermatologists
    - older studies in this assessment may not reflect contemporary technologies for the capture, transfer and assessment of dermatological images.
- The main safety concern is that clinically significant incidental lesions may be missed as a result of fewer in person examinations. Actions to mitigate this risk will be required.
- Undertaking image capture in primary care settings means that the time taken for GP consultations is likely to increase for patients requiring teledermatology referrals when compared with conventional primary care referral processes.

Cost effectiveness

- In the only identified systematic review, 11 economic studies compared SAF TD with conventional face-to-face consultations for triage of referrals. Nine studies concluded that SAF TD was cost saving, with the remaining studies demonstrating cost equivalent.
- In six primary studies comparing SAF TD with conventional face-to-face consultations for triage, four studies found SAF TD to be cost saving, while two studies found that SAF TD was associated with increased costs (four cost analyses; one cost-minimisation analysis; one cost effectiveness analysis).
- A de novo cost consequence analysis for NHSScotland estimated that increased uptake of a SAF TD referral triage system would likely lead to a reduction in healthcare resource use, decreased travel requirements and costs for patients, leading to decreased carbon emissions.

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Definition

Store-and-forward teledermatology – a process in which patient information such as photographs, historical and background information are sent as digital files to a dermatology clinician who reviews the data hours or days later. No direct interaction is necessary or possible because the interacting parties are separated in time and location. [1]

Introduction

The term teledermatology encompasses many formats, purposes and models of care. This evidence assessment concerns the use of TD to review new patients and assess their need and urgency for dermatological care.[2] In this teletriage model referral information is reviewed by a dermatologist who makes and communicates a management plan which, may include: in-person consultation; direct booking for a procedure; surgery or other treatment; advice for the referrer on how the patient may be managed in primary care with or without a follow up appointment; and discharge with reassurance without the need for follow up.[3] The TD consultation does not replace the need for, or function as a surrogate for, in-person visits for every person referred.[4]

Teledermatology triage is in place in some part of NHSScotland. There is variation across NHSScotland boards as to the proportion of referrals from primary care to secondary care dermatology which include photo-documentation of sufficient quality to support triage of referrals. The proportion ranges from 30% to 90% of referrals for lesions and only a very small proportion for other skin conditions such as acne and rashes (J Cochrane, Head of Programmes, National Centre for Sustainable Delivery. Personal Communication, 05/10/2022).

This SHTG report will contribute to a business case under development by ANIA that will be considered by the Innovative Device Authority. If approved, ANIA will engage with health boards to ensure an efficient roll-out of this technology.

Research question

The parameters of the research question are set out in *Table 1*.

Table 1: Parameters of the research question

Population	Patients (adults and children) who require new referral from primary care/community care to secondary care dermatology
Intervention	Inclusion of photo-documentation with all referrals to facilitate teledermatology triage Photographs may be taken by patients or carers, GPs, medical photographers
Comparator	Current practice–written descriptive referrals without photo-documentation
Outcomes	▪ Waiting times for patients with all referred conditions (variously defined) ▪ Time to treatment/advice/reassurance for all conditions ▪ Number of face-to-face specialist consultations ▪ Proportion of referred patients managed virtually (without face-to-face appointment) ▪ Proportion of patients redirected (from secondary care dermatology) to specific pathways, eg advice only, surgery, phototherapy, treatment in community/primary care, onward referral to other specialties ▪ Quality of life ▪ Satisfaction, views, preferences of all stakeholders ▪ Safety/harms – eg missed cancers as a result of fewer in-person visits for full body clinical examination ▪ Equity around access/use of technology/ethnicity skin tones ▪ Cost effectiveness
Limits	From 2005, English language
Excluded	Studies that examine and compare image quality. Studies that compare diagnostic accuracy/inter-rater agreement and diagnostic concordance of remote and in-person assessment

Literature search

A systematic search of the secondary literature was carried out between 5 and 6 September 2022 to identify systematic reviews, meta-analyses, health technology assessments and other evidence based reports. Databases used included: Medline, Medline in process, Embase, Cochrane, Web of Science and Epistimonikos.

The primary literature was systematically searched between 15 and 20 September 2022 using the following databases: Medline, Medline in process, Embase, HMIC, ASSIA, Cochrane. Results were limited to English, 2005-2022.

Key websites were searched for guidelines, policy documents, clinical summaries, economic studies.

Concepts used in all searches included: teledermatology, teledermoscopy, digital dermatology, primary care, general practice. A full list of resources searched and terms used is available on request.

Health technology description

The health technology examined in this review is the addition of photo-documentation to each referral made from primary care to secondary care dermatology to facilitate TD triage. Digital images may be captured by any device including smartphone, tablet or digital camera and photographs may be provided by GP, patient or medical photographer. Magnified images (dermatoscopy) may be included. Images may be transmitted to or shared with secondary care using a photo capture and pass-through (PCP) app or other secure data system and linked to patient medical records.

Epidemiology

Based on data from 2012, around 12% of primary care consultations in Scotland concern skin disease.[5]

The incidence of skin cancer in the Scottish population is increasing. The European Age Standardised incidence for malignant melanoma (MM) in Scotland has increased from 15.4 (95%CI, 14.3 to 16.7) per 100,000 person years at risk in 1996 to 28.1 (95%CI, 26.7 to 29.6) in 2019. For non-melanoma skin cancers the rate has increased from 143.1 (95%CI, 139.0 to 147.3) in 1996 to 244.4 (95%CI, 240.1 to 248.8) in 2019.[6]

In 2020, MM was the fifth most common cancer in women and the sixth most common cancer in men in Scotland.[6] There were 1,183 newly recorded cases of MM in Scotland in 2020. This was lower than each of the six previous years with the reduction likely to be

associated with measures relating to the COVID-19 pandemic. The number of new MM cases in 2019 was 1,496. There were 11,940 cases of non-melanoma skin cancer, including basal cell carcinoma (BCC) and squamous cell carcinoma (SCC), in Scotland in 2019.[6]

In an analysis of data from NHS England from 2013 to 2017, melanoma skin cancer was the fifth most common cancer site for people in the White ethnic group but was not in the 20 most common cancers for people in the Asian, Black or Mixed/Multiple ethnic groups.[7]

In a Scottish analysis from 2010, around 43% of new patients referred to secondary care dermatology had benign or malignant skin tumours and 58% of referrals were for patients requiring diagnosis.[8]

From 2019 to 2020, the total secondary care dermatology expenditure in NHSScotland was £68.9 million (M). Of this, £65.4M was associated with outpatient appointments (n=500,082) and the remainder associated with day case and inpatient episodes.[9]

At 30 June 2022 there were 44,152 patients waiting for a dermatology outpatient appointment in NHSScotland of whom 22,197 had been waiting for longer than 12 weeks. Of patients newly seen in outpatients departments 7,925 had been waiting for longer than 12 weeks and 5,724 had been waiting longer than 16 weeks.[10]

Clinical effectiveness

Systematic reviews and guidelines

No systematic reviews or guidelines were identified which focused specifically on TD for triage of primary care referrals.

Several reviews were helpful in identifying relevant studies.[1, 11, 12-14] These reviews searched in only one or two databases so were not methodologically adequate for their overall findings to be included in this assessment.

Randomised controlled trials

Six RCTs were identified and have been summarised in *Table 2*. There was no consistency in the outcome measures used across the studies.[14]

Several issues affect the applicability of these RCTs to the Scottish context:

- in some studies use of the triage system was at GP discretion as an additional tool for receiving advice and guidance rather than applied to all cases where secondary care referral was being considered

- recruitment criteria may have excluded groups of patients which the proposed Scottish model would encompass, such as people with more than one skin condition
- in some healthcare contexts, patients were able to consult with a secondary care dermatologist independently of referral from primary care, so the profile of interaction between GP and secondary care may not reflect Scottish practice
- established regional referral patterns based on, for example, historical levels of access to, or waiting times for specialist dermatology, may be confounding factors
- dermatologists taking part in these trials may have been able to provide a faster response than would be achieved in routine practice.

A trial conducted in Germany between 2018 and 2019 randomised four matched pairs of counties to a 12 month SAF TD intervention.[15] Matched pairs were used to minimise confounding by geographic features such as population density and healthcare capacity. GP practices (N=46 practices, 439 teleconsultations) implemented the system at their own discretion. There was no instruction to use for all eligible patients which may limit applicability to the current assessment. Patients aged ≥18 years presenting with skin complaints were recruited. For the intervention group, GPs were trained in the process and used a digital camera, or dermatoscopy if appropriate, and uploaded images and clinical information to a TD system. Each case was sent to a teledermatologist for assessment within 48 hours. In control group GP practices (N=342) patients received care as usual. The primary outcome was number of patient referrals to dermatology. A dermatologist referral was defined as a health insurance bill for dermatology service in the same quarter that the patient had a primary care visit. No significant differences were identified between referral rates in control and intervention practices when adjusted for practice characteristics, patient characteristics and regional matching (relative risk of referral=1.02, 95%CI 0.91 to 1.14, p=0.74). Feedback was collected from intervention GPs and teledermatologists within the TD system. Intervention GPs made 439 teleconsultations and for 79% of cases stated that that without the system they would have made a patient referral. When asked if they will still refer once they have received the result of the teleconsultation, 53% of those cases with a response (n=223) recorded 'yes.' Data were missing for 49% of the cases. When the teledermatologists were asked if a physical referral to a dermatologist was necessary the answer was 'no' for 47% of cases, 'yes' for 38% of cases, and 'cannot say' for 15% of cases. For 79% of cases where a response was provided (n=278) the teledermatologists described image quality as sufficient for their diagnostic findings.

A small French trial which took place over six months in 2014 randomised groups of GPs to usual care (n=4 clusters, 19 GPs, 50 patients) or a SAF TD intervention (n=4 clusters, 20 GPs, 53 patients). [16] Patients aged ≥18 with a skin condition were eligible. Patient exclusion criteria included need for urgent medical care and needing a technical procedure, this latter exclusion category encompassed patients with suspected skin cancer where biopsy would be considered. The intervention involved GPs submitting photographs (from a mobile phone

or digital camera) alongside a standardised patient information template to access dermatology opinion. Data was submitted using a secured email inbox. The mean time taken for GPs to process the referral in the intervention group was 25.1 minutes compared with 10.4 minutes in the control group. Dermatologists replied with a diagnosis and management plan or an appointment for a patient consultation. In the control group, patients were given a standard referral letter and instructed to consult with a dermatologist of their choice. The primary outcome was the delay between initial GP consultation and start of treatment including medication or watchful waiting. In the intervention group the teledermatologists put forward a treatment plan for 73.5% (n=39) of patients, with specialist dermatology follow up consultation required for 14 patients. For the remaining 14 (27.5%) patients the dermatologist was not able to recommend a treatment plan and so organised an in-person consultation. In total, 25 (47.2%) requests did not require a face-to-face consultation with a dermatologist and were designated as consultations avoided. The median delay to starting treatment was four days in the intervention group and 40 days in the control group. The overall hazard ratio for delay was 2.55, $p<0.011$ when adjusted for clustering of GPs and which dermatologists were consulted. The quality of photographs was insufficient in 11 cases (20.75%). An unvalidated Likert scale was used to assess patient and GP satisfaction. No differences between intervention and control participants were identified.

One study from the United States (US) randomised military veterans who required a dermatology referral to either SAF TD or usual care. Digital photographs were taken at baseline and follow up for both study groups.[4, 17] There were 1,163 patients assessed for eligibility with 392 agreeing to take part and randomised (196 to each study group). For Around 40% of those assessed as eligible declined involvement. A further 7% had skin conditions which were not visible. The primary outcome was quality of life (QoL), using the Skindex-16 assessment at three and nine months. A secondary outcome was clinical course, with a panel of dermatologists classifying the skin condition as 'resolved,' 'improved,' 'unchanged' or 'worse.' The study may not have had sufficient power for this outcome. During the study period, 62% of the TD patients and 88% of the conventional care patients had at least one dermatology clinic visit. QoL scores reduced for both groups indicating clinically significant improvement at both three and nine months from baseline. There was no statistically significant difference between groups. Data were missing for 67 (17%) of the patients which introduces uncertainty to the findings. The ratings for clinical course at nine months were not significantly different between study groups with most frequent rating category in both groups being 'improved.' Around 98% of study participants were males aged in their early sixties which limits the generalisability of this study to a wider population.

A Dutch RCT conducted between 2004 and 2006 randomised GP practices to teledermatological consultation or standard referral procedures which involved a visit to an outpatient clinic with a letter from the GP describing the case.[18] Patients requiring

emergency consultation within two days were excluded. Teledermatology involved submission of patient details and four digital images of the skin problem (two close up and two wider views). Dermatologist feedback was provided by email within 48 hours. Patients in both the intervention and control groups were seen by a dermatologist at approximately one month from GP visit reflecting the standard wait time for dermatology. The primary outcome measure was the proportion of preventable consultations as judged by the dermatologists. A preventable consultation was defined as where GPs tests and/or treatments based on the dermatological advice was successful and the patient recovered or was recovering. Reasons why a consultation had been preventable or non-preventable were logged by the dermatologist immediately after each patient consultation. There were 327 patients (from 18 practices) in the intervention group and 293 patients (from 16 practices) patients in the control group. Data were missing for almost 40% of patients as a result of their not visiting the dermatologist, visiting a dermatologist not participating in the study, or dermatologists not completing study logs. Authors noted that GPs might have been selective in inviting patients to participate despite instruction to invite all eligible patients. Both these factors will introduce bias. For patients with complete data in the intervention group (n=200) 39% of consultations were designated as preventable compared with 18.3% in the control group (n=169), the difference was 20.7%, 95%CI (8.5% to 32.9%). The most frequent reason for a preventable consultation in the intervention group was 'patient recovered or recovering.' The most frequent reason for non-preventable consultation was that the 'dermatologist was required for treatment' which accounted for 43.5% of cases in the intervention group. The largest number of preventable consultations in the TD group were for eczema and infections. A shortened version of a questionnaire to measure satisfaction with medical care found no evidence of a difference in patient satisfaction between groups.

A trial from the US randomised adult military personnel (n=698) requiring dermatologist referral to a SAF TD consultation or usual care.[19] Patients were excluded if they had multiple skin complaints, an emergency skin condition or desired full body screening examination. The primary outcome was clinical outcome recorded as 'improved,' 'no change' or 'worse' based on digital images taken at baseline and four months, assessed by a dermatologist blinded to randomisation assignment. There was no difference between study groups in clinical outcomes, with just under two thirds of cases in both groups described as 'improved,' around a third of cases having 'no change' and a small proportion (3-4%) being assessed as 'worse.' Baseline for the TD group was initial consultation in primary care whilst for the usual care group baseline was the first dermatology clinic visit which was between two and three months following the primary care consultation. This difference led to greater numbers of participants in the usual care group not presenting for the baseline visit and will introduce bias to the study limiting the reliability of the finding that the two consultation formats provided similar outcomes.

One UK health technology assessment published in 2006 randomised adults aged ≥16 requiring a consultant dermatologist opinion to SAF TD (one or more digital images) or usual dermatology outpatient care.[20] The primary outcome was clinical equivalence as measured by agreement between consultant and independent second opinion as to an appropriate management plan. Patient and GP satisfaction was also assessed. The study failed to achieve the recruitment target of 446 in each group; only 208 patients were recruited. Loss to follow up was greater in the control group than in the intervention group which will have introduced bias. Further bias was introduced owing to the independent second opinion being provided much later for the intervention group compared with the control group. For TD cases, the second opinion was in line with the teledermatologist management plan for 55% (51/92) of patients compared with 84% (61/73) of control cases. This difference was statistically significant. The time between referral and delivery of electronic opinion to the GP was shorter in the intervention group, with mean wait time 13 days compared with 67 days ($p<0.0001$). Levels of patient satisfaction were high in both study groups with no evidence of a statistical difference between groups. The survey of GPs identified factors which could have been improved such as the increased workload associated with the TD system, the complexity of the referral process and the reliability of the software connection. The authors stated that no valid conclusions could be reached on the clinical performance of SAF TD as a result of the issues around recruitment and bias.

Table 2: summary of RCTs

Trial/Country	Patient population	Unit of randomisation/ number of patients	Intervention	Outcome measure(s)	Notes/Key findings
Koch (2022)[15] Germany	Aged ≥18 year presenting with skin complaint and consenting to teledermatology Mean age: Control 56.95 Intervention 56.26 % males: Control 40.08 Intervention 41.89	German counties (N=8 in 4 matched pairs) with implementation at GP practice level. Intervention practices N=46 Control practices N=342 Total number of intervention cases =439	Teledermatology used at GP discretion 12 months SAF teledermatology triage (digital images plus dermatoscopy if appropriate) supplied by GPs Response from dermatologists within 48 hours	Number of patient referrals per quarter to dermatologistsover a 12-month intervention period (converted to rates) with GPs practices as unit of observation GP and dermatologist feedback survey	Potential for selective inclusion of patients No significant difference in referral rates between control and intervention practices (relative risk=1.02, 95%CI 0.91 to 1.14, p=0.74) Data missing for 49% of cases
Piette (2017)[16]	Aged ≥18 year presenting with	Clusters were groups of GPs in	GPs took at least three pictures of the	The delay, in days, between the initial GP's	Quality of photos insufficient in 21% of cases

France	skin condition and GP required dermatologist opinion Mean age: Control 43.5 Intervention 44 % males: Control 50 Intervention 30.2	same medical facilities Intervention GPs (N=20, 50 patients) Control GPs (N=19, 53 patients)	patient's skin lesion and sent them by secured email along with a written message to dermatologists. Whenever they received a teledermatology request, they replied with a diagnosis, possible differential diagnoses, and/or a management plan	consultation and the dermatologist's reply	The median delay between the initial GP consultation with patient and the dermatologist's reply in order to begin care was four days in the intervention cluster and 40 days in the control cluster. Adjusted hazard ratio for not having received a dermatologist opinion was 2.55, p=0.01

Whited (2013)[4, 17] US	Veterans being referred from primary care to dermatology – new referrals Excluded – emergency cases, more than one skin condition and full body examination requested <u>Mean age</u>: Control 62.9 Intervention 61.7 <u>% males</u>: Control 98 Intervention 97.4	Patients Conventional care (n=196) Teledermatology (n=196) Mainly white males	At least two images taken by GP using digital camera according to an imaging protocol Response from dermatologist recommending visit or providing diagnosis/management plan	QoL Clinical course assessed from images at baseline and nine months by three independent dermatologists blinded to allocation	Data missing for 17% of patients No statistically significant differences were observed in QoL or clinical course when comparing teledermatology patients with those who received conventional care
Eminović (2009)[18] Netherlands	Patients being referred by their GP to one of the recruited dermatologists and did not require a dermatologic	GP practices Number of patients Intervention n=327 Control n=293	4 digital images of the skin problem attached to semi structured form submitted via secure website – response from dermatologist within 48 hours	Proportion of and reasons for preventable consultations	Outcome data were missing for 39% of cases 39% of consultations deemed preventable in intervention group compared with 18.3% in the control group indicating a potential

	consultation within 2 days Mean age: Control 44 Intervention 42 % males: Control 65 Intervention 71		All study participants assessed in-person by dermatologist at approximately one month		20.7% reduction in referrals as a result of the teledermatology intervention
Pak (2007)[19] US	Adult military personnel requiring dermatologist referral Excluded if multiple skin complaints, emergency skin condition or desired full body screening examination Mean age: Control 47 Intervention 44 % males: Control 34 Intervention 29	Patients teledermatology n=351 (272 completed) Usual care n=347 (236 completed)	History and digital camera images transmitted to a server for subsequent review Control group patients also had images taken at baseline (their dermatology visit around 2-3 months after the consultation was scheduled after GP visit) but these were used only for clinical course evaluation and not transmitted for teledermatology	Clinical course rated on three point scale: Improved No change Worse Based only on images	There was no evidence to suggest a difference between the study groups in the clinical outcomes at four months

Browns (2006)[20] UK	Adults ≥16 Requiring dermatologist opinion <u>Mean age</u>: Control 49.7 Intervention 43.6 <u>% males</u>: Control 38 Intervention 37	Patients (n=208 randomised)	SAF dermatology (one or more digital images) compared with usual outpatient care	Concordance with management plan between teledermatology and face-face dermatology opinion	The authors stated that no valid conclusions could be reached on the clinical performance of SAF TD as a result of the issues around recruitment and bias.

Observational studies from the UK

Comparative studies

A Scottish study of patients (mean age 51 years, adults and children) referred by their GP for an urgent appointment for suspected skin cancer compared the outcomes of conventional electronic letter referral for dermatology outpatient appointment at a dermatologist-led skin cancer clinic (n=231), with a TD triage process (n=411).[21] GPs had a free choice of which system to use and the study ran for six months in 2008. In the TD process, referral was made by way of a dedicated skin cancer electronic referral system with patients booking to attend for professional medical photography imaging (four high quality images including dermatoscopy) in a community setting. Images were examined by a consultant dermatologist alongside clinical information from the GP. Dermatologists allocated patients to either a consultant-led skin cancer clinic, a nurse-led clinic, nurse-led cryotherapy, surgery, photodynamic therapy or to another specialist such as a maxillofacial consultant. As a safety measure in this study, no patients were referred back to their GP and patients who did not attend booked photography sessions (n=90) were offered appointments as per the conventional pathway. Data were complete for 289 patients in the TD triage pathway. Eighty-two (28.4%) were triaged to the consultant-led clinic, 121 (41.9%) were triaged to nurse-led clinics and 63 (21.8%) were triaged direct to surgery. The remainder (n=23) were triaged either photodynamic therapy, to a community clinic led by a GP with special interest, or to another specialty. Reasons for incomplete data (n=122) included patient-initiated cancellation or non-attendance at a clinic to which they were triaged. Direct booking of surgery in the photo-triage pathway meant that a greater proportion patients referred by this route received definitive care (surgery or reassurance, 91%) at their first encounter with the specialist team when compared with standard referral (63%). Rates of surgery were similar in the two comparator groups and similar proportions in each group had benign lesions. Waiting time to definitive care for skin cancer patients was shorter in the photo-triage group. Mean waiting times for patients with MM (n=294), SCC (n=32) and patients with BCC (n=29) were, respectively, 39, 50 and 58 days for patients referred conventionally, and 36, 28 and 35 days for patients referred through the TD triage pathway.

Another Scottish study compared TD triage for patients with melanoma or SCC at a skin cancer clinic with conventional referral.[22] The study was published as a concise report and may not have undergone peer review. It is unclear how patients were selected for TD triage. GPs initiating a TD triage referral completed a proforma on a website and were then able to book a medical photography appointment for their patient. Three high quality images, including dermatoscopy, were taken using a digital camera and loaded onto a server. The consultant dermatologist viewed all online referrals and allocated priority, classifying cases where melanoma or SCC was suspected as 'urgent.' Data were collected prospectively and compared with data for patients with skin cancers referred conventionally (n=76) for the year to May 2006. There were 451 patients referred through the TD triage route. Of these, 14 had melanoma and six had SCC. All but one of these patients were prioritised as urgent. The remainder had BCC (n=51) or non-malignant lesions (n=380). In the conventional

referral group, only 41 of 76 (54%) patients with skin cancers were prioritised as 'urgent.' Median waiting time to clinic for patients with melanoma referred through TD triage was 14 days (range 1-34). For patients with melanoma referred conventionally and prioritised as urgent (26/39) the median waiting time was 24 days (range 6-59). There were a further 12 patients with melanoma referred conventionally for whom the waiting time to clinic was longer as they had been prioritised as 'soon' or 'routine.' For these patients the waiting times ranged from 8 to 177 days, with data missing for one patient. For patients with SCC, median waiting time to clinic visit was 13.5 days (range 11-19) in the TD triage group. This compared with 24 days (range 1-42) for patients with SCC referred conventionally and prioritised as 'urgent' (n=15). There were a further 22 patients with SCC referred conventionally for whom waiting times for clinic was longer as they had been prioritised as 'soon' or 'routine.' For these patients waiting times ranged from 19 to 179 days. The reasons for longer wait times for patients prioritised as urgent in the conventional pathway were not explained although the authors noted that visualising lesions might encourage clinicians to see a patient earlier. Waiting times from referral to treatment were correspondingly shorter in patients with melanoma or SCC whose referral included photographs.

Non-comparative studies

One retrospective study described the outcomes of a medical photography based TD service in London between 2017 and 2020.[23] Patients consulting a GP for a skin lesion were referred to the TD service and could book an appointment for medical photography (wide, close up and dermatoscopic images) in a GP practice or local community hospital. Consultant dermatologists examined the images alongside referral information and could refer back to GP with reassurance or treatment plan, refer direct to surgery or provide the patient with a face-to-face dermatology appointment. Patients with more than three lesions, those with anogenital lesions, children and those requiring urgent attention were excluded from the study. Of the total 8,352 TD consultations, 4,748 patients (56.8%) were referred back to their GP. Referrals direct to surgery accounted for 1,634 (19.6%) cases and 1,970 patients (23.6%) were offered face-to-face appointments. To assess the impact of the service on the proportion of face-to-face appointments the authors compared three six-month periods in 2017, 2018 and 2019. Between 2017 and 2019, TD referrals increased from 19% to 46% of all referrals. Routine referrals decreased from 37% to 29% of all referrals. Urgent referrals made up 31% of all referrals in 2017 and 35% in 2019. The average waiting time for a TD clinic slot was three weeks compared with 30 weeks for a routine face-to-face dermatology appointment. Three audits of the safety of the TD process were made. The first was to invite 50 patients discharged back to GP to a clinic to conduct a full body skin examination (FBSE). No detail was given on how these patients were selected. Only one patient had a suspicious lesion identified which was confirmed as a dysplastic naevus. In a review of 10 cases, again without detail around selection, where photographs had been taken and biopsy was undertaken, assessment of images by five consultants was compared. The only discrepancies between opinions were whether the patient should be referred direct to

surgery or be seen face-face first. The third safety audit examined the cases of 32 patients who were re-referred within 12 months of being discharged to primary care. Only two patients were re-referred for the same lesion. Patient satisfaction was assessed using a bespoke patient experience questionnaire (n=59) but no information was provided on response rate or how patients to be surveyed were selected. The authors of this study identified and set out the findings of nine relevant analyses published as conference abstracts or brief research communications describing outcomes of other TD services in the UK. Across these, the proportion of patients referred back to the GP or managed in the community ranged from 26% to 68%.

A retrospective review of a SAF TD service in NHS England examined cases from July 2004 to July 2018.[24] GPs referred into a nurse-led TD clinic where a detailed patient history was taken and skin examination performed. High quality digital images were taken using a digital camera with a dermatoscopic attachment. Information and images were delivered to reporting dermatology consultants using an internet-based platform. There were a significant amount of missing data which the authors noted mostly occurred in the early years of the service when data fields were not mandatory. There were 40,201 cases, of which 64% were coded with a diagnosis (n=25,555). Of the coded records, 77% were lesions and 6% were dermatoses. The remainder were diagnosis not made or diagnosis pending. The most frequently recorded lesions were benign naevus (25%), seborrhoeic keratosis (22%) and BCC (19%). The most frequently recorded dermatoses were eczema (32%), acne (20%) and rosacea (5%). For patients who had been assessed and had information recorded, 50% were referred back to GP with advice, 34% were booked directly for surgery including biopsy or excision and 16% were offered a face-to-face appointment. The authors undertook a detailed analysis of reasons for diagnosis not being made for 383 patients identified in records for 2015. Reasons for diagnostic uncertainty included awaiting biopsy findings or histological confirmation, lesions difficult to characterise, photographic images not clear or from difficult body sites such as hair bearing areas or umbilicus. There was variation between the four reporting consultants as to proportion of unrecorded diagnoses suggesting variation in levels of experience and caution.

International observational studies

Observational studies from the US were excluded based on the lack of comparability between the US and UK healthcare systems. Studies from European countries, Canada, Australia, New Zealand and Brazil were included.

Comparative studies

Three comparative observational studies were examined.[25-27]

A Swedish study carried out in 2012 compared the outcomes of referrals for suspected cancer from primary healthcare centres (N=20) recruited to use a smartphone-app-based teledermatoscopy (TDSc) system, with outcomes from consecutive referrals to the same

hospitals from centres which were using traditional paper-based referral.[25] Excluded subjects were people under age 18 and those with a lesion which could not be photographed. For the TDSc group (n=902, 816 analysed) GPs captured one clinical and one dermatoscopic image and completed a standardised form for collecting clinical information. Only one lesion could be referred at a time. Standard triage responses included: nature of the lesion with dermatoscopic description, possible diagnosis, priority and suggested management (none, medical therapy, destructive therapy or surgery). Only four out of 902 TDSc referrals had images which were considered insufficient quality for use in triage. Patients referred using the traditional system (n=918, 746 analysed) were triaged to hospital appointment based on information from the GP sent by post. All study subjects were invited to a face-to-face dermatology appointment to evaluate the safety of the TDSc process and exclude incidental findings. Patients who did not attend were excluded from the study. Patients who required surgery and who had a final diagnosis of melanoma, SCC or BCC had a statistically significantly shorter waiting time for their first visit with a dermatologist and for their surgery in the TDSc group when compared with the paper-based referral group. Patients with melanoma had a median time to visit of 9 days in the TDSc group compared with 14 days in paper-based referral group. Median time to surgery was 9 days in the TDSc group compared with 35 days in the paper-based referral group. This difference was attributed to the longer time for the postal referral to be received and assessed and more accurate allocation of priority in the TDSc group. The median Breslow thickness of the invasive MMs in the TDSc group was 1.0 compared with 2.2 in the control group. For patients referred through TDSc 42% (n=346) had lesions assessed as benign and, outside of this study context, may have avoided a face-face visit. Of this group, three patients had actinic keratoses, which would have been missed. Malignant incidental findings were recorded in 14.3% of the TDSc group and 13% of the paper-based referral group. This included 12 MMs (0.8% of full patient population). The study authors included the app developers and the dermatologists who assessed the TDSc referrals.

A study from New Zealand conducted in 2012/13 reported on the first year of a TDSc virtual lesion clinic for triage of primary care referrals for people with skin lesions suspicious for melanoma.[26] Patients attended a nurse-led local imaging clinic where macroscopic and dermatoscopic images were captured and clinical information recorded. Images were reviewed remotely by experienced teledermatologists who were able to recommend: specialist assessment, excision of lesion(s), reimaging in three months, discharge to GP for management (topical medication or cryotherapy), self monitoring or reassurance of no concern. During the one year period 345 patient visits were triaged in the virtual clinic, of which 35 patients did not attend for imaging. Most patients (58%) presented with a single lesion and for 197 (64%) patients specialist care was not required. For those patients referred back to their GP, 26 were recommended to have reimaging in three months and 45 had recommendations for GP treatment. The median wait time from receipt of referral to first specialist assessment was 9 days which the authors compared with a median wait time of 26.5 days for a standard face-face clinic. The authors note that this facilitated a reduction of 17.5 days wait time to surgical excision of lesions. No data were given about how these comparators were arrived at.

A Spanish study compared the initial melanoma prognosis of patients (n=67) referred to dermatology through a well-established TD network which had been in operation for triage of suspicious pigmented lesions for four years, with outcomes of patients referred conventionally (n=134).[27] The patients referred conventionally were described as 'from geographical areas not joined to the TD network'. It is possible that these patients were given less priority, which may bias the study findings. Data from 2006 to 2010 were analysed and the mean Breslow thickness for patients in the TD group was lower than for the comparator group (1.06 mm compared with 1.64 mm, p=0.03). For the TD group 70.1% of patients had tumours at an early stage (Tis and T1a) compared with 56.9% in the conventionally referred patients, odds ratio 1.96 (95%CI 1.14 to 3.50). This benefit was seen when the four-year study data were analysed but for each of the study years analysed separately there was no statistically significant difference between groups. This may indicate that the study was underpowered. In addition to linking lower Breslow thickness with shorter waiting times the study authors also postulated that system factors may have played a role. Factors included better knowledge amongst GPs because of ongoing teledermatologist feedback, lower thresholds for referral and the knowledge of the system by citizens who were aware they could have a rapid opinion and so may come forward earlier.

Non-comparative studies

Nine large descriptive single arm observational studies from European countries and from Canada were identified but not examined given their limited applicability to NHSScotland. Outcomes such as waiting times and proportion of outpatient visits avoided are dependent on the specific healthcare contexts, geographical factors and the patient groups considered.[28-36]

A retrospective study from Brazil is included to provide information on triage of paediatric referrals.[37] A cohort of 6,879 patients aged 19 and under (n=10,685 lesions) were recruited to TD triage. Health technicians captured clinical photographs and uploaded them, along with clinical history, via a mobile app to a digital dermatology platform. Cases were reviewed by a dermatologist who had three options for each lesion: refer for biopsy; organise face-face dermatologist visit; or refer back to primary care with probable diagnosis and recommendations for primary care investigations and management. Referrals back to the primary care paediatrician occurred in 54% of cases. Only 1% of patients were referred directly for biopsy. The remaining 45% of patients were scheduled to visit a dermatologist. Photographs were of insufficient quality in 1.4% of cases and these cases were referred for in-person assessment. Where analysis was conducted per lesion, 62% of lesions assessed led to the patient being referred back to the primary care paediatrician whilst 37% required a face-to-face dermatology visit, with 1% triaged direct to biopsy. For children aged up to 12 years the most frequent diagnoses were atopic dermatitis and pityriasis alba. For teenagers the most frequent diagnoses were acne, atopic dermatitis and melanocytic naevi. Referrals to dermatology were mostly made for treatment of infectious diseases or conditions such as

psoriasis and alopecia which require follow up. Benign neoplasms were also referred to dermatology for dermatoscopy. The authors note that referrals could have been reduced if dermatoscopic images had been available. Emollients and topical corticosteroids were the most frequently prescribed medications. During the project mean waiting time for a face-face dermatology appointment was 1.5 months compared with 6.7 months before the project. No detailed information was provided on how this was calculated.

Ongoing studies

No ongoing studies of TD triage of primary care referrals were identified.

Safety

A general safety concern with TD is that clinically significant lesions may be missed since a detailed or FBSE by a dermatologist is not possible.[25] A Scottish study prospectively examining the rate of incidental melanomas detected through FBSE at a skin cancer clinic found that without FBSE a third of melanomas in their patient population would be missed.[38] Most of the patients with incidental melanomas were referred with benign lesions indicating that the most relevant index lesion had not been selected for attention of the dermatologist. The authors noted that their patient group, who were referred with a suspicious lesion(s), will have a higher rate of incidental melanomas than the wider dermatological patient population. This is also acknowledged in a more recent UK cohort study which reported that, of 4,726 patients attending a clinic for people referred with suspected skin cancer, there were 191 (4.04%) who had malignant incidental lesions detected on FBSE. For patients with a clinically benign index lesion the rate of malignant incidental lesions was 1.72% (53/3072) whilst for those with clinically suspicious index lesions requiring biopsy the rate was 8.34% (138/1654).[39] A Cochrane systematic review of TD for skin cancer diagnosis identified six studies of referral accuracy, only one of which was specific to primary to secondary care referral.[40] In addition to highlighting the potential to miss around 10% of lesions where clinical action could be required the review suggested that TD could recommend an action for lesions which, if seen in-person, may be considered of less or no concern. These studies are not directly relevant to TD for triage of unselected referrals from primary care but may inform mitigations. For example, Borve (2015)[25] suggests that a reminder about the importance of FBSE be added to standardised responses to GPs.

Patient and provider satisfaction

A 2016 systematic review identified studies which used quantitative data to measure patient and provider satisfaction with SAF TD.[41] Studies were not only concerned with initial referral to dermatology but included other SAF contexts including screening, wound care, treatment monitoring and education. Thirty-three studies were identified, of which 11 were from the US, with the others from countries including the UK, Austria, the Netherlands and Australia. Studies varied in how satisfaction was assessed with measurement scales ranging from two items (for example yes/no) to 10-point scales. In order to standardise across studies, for the purpose of the review the authors devised criteria to convert each scale into responses demonstrating satisfaction or not demonstrating satisfaction. These criteria were used to infer satisfaction was achieved where ≥80% of participants in a study reported responses indicating satisfaction. Eight studies reported both patient and provider satisfaction. For patient satisfaction, outcomes across 24 studies included overall satisfaction, comfort with remote diagnosis, willingness to use again, willingness to recommend, satisfaction with accuracy and reliability, equivalence with face-face interaction and satisfaction with information and quality of service. There was only one study where the threshold for demonstrating satisfaction was not met. There were 17 studies assessing provider satisfaction with SAF TD. Outcomes measured were overall satisfaction, acceptance, usefulness, willingness to continue using, and willingness to recommend. Providers included primary care physicians, referring nurses and consulting dermatologists. For only three of the 17 studies the threshold for demonstrating satisfaction was not met.

As part of a TD project in Brazil, dermatologists (n=12, who had each reported on ≥1,000 lesions) were surveyed as to their perceptions of the utility and limitations of the SAF system.[42] All indicated that they wished to continue using TD. Confidence in using TD increased over the 1-year project. Limitations were expressed specific to the software used, such as not being able to specify the urgency of need for a face-to-face appointment and inability within the software to directly refer to other specialties such as orthopaedic or vascular surgery. When asked about confidence in diagnosing specific conditions the need for dermatoscopic images was identified as important. Only two out of 12 teldermatologists were confident diagnosing malignant tumours without dermatoscopy and only three out of 12 were confident diagnosing atypical naevi without dermatoscopy. Most participants were confident diagnosing from clinical images for xerotic eczema, pigmentary disorders and superficial infections.

A pilot study of a primary care smartphone TDSc project in Belgium to triage patients with pigmented lesions to a dermatology appointment within typical time intervals or to be seen urgently (within 2 weeks) explored GP (n=6) satisfaction with the system.[43] Satisfaction with ease of fitting the system into daily practice, time required to capture images, and the

resulting report and advice was high, ranging from 8.6 to 9.6 out of possible score of 10. Satisfaction was similarly high that the project brought health benefits for patients and improved diagnostic competency. Patients (n=19) had confidence in the technology, trusted the advice and would be willing to repeat the experience.

Patient and social issues

Three editorial reports and commentaries were identified highlighting issues around photographing and diagnosing skin pathologies in people with a diversity of skin tones.[44-46] It may be more difficult to make a confident diagnosis from photographs of patients with pigmented skin (Fitzpatrick skin types IV to VI), for example it is difficult to recognise erythema and assess lesions. Patients may be less likely to benefit from advice where the referral relies heavily on clinical images to aid diagnosis. In the context of long waiting times for non-urgent referrals this could be a disadvantage (F Macdonald, Clinical Lead for Dermatology, NHS Greater Glasgow & Clyde, Personal Communication, 01/11/2022).

The potential for a digital divide where TD patients and practitioners in specific health facilities may not have adequate skills, equipment or infrastructure to participate was also highlighted.[44]

Teledermatology triage may save costs for patients as a result of reduced unnecessary travel and time off work.[23]

Organisational issues

Expanding TD triage will have an effect on the work profile of primary care practitioners, clinical photographers and dermatologists including consultation time, patient contact, workload, work patterns and flexibility. [23] GPs may require training in image capture and TDSc. [47 48] Quality standards for TD using SAF images were published in the UK in 2013 by Primary Care Commissioning.[49]

There may be overlap between current advice and guidance services provided to GPs by secondary care dermatologists and referral into TD triage processes. In NHSScotland there is variable use of advice and guidance services across health boards with a range of methods of communication and record keeping in place. There is no standardised audit of these consultations. In England, some systems offer the facility to convert an advice request into a referral (https://www.bad.org.uk/clinical-services/teledermatology/advice-and-guidance-and-e-referral-service-e-rs-in-dermatology/). Having access to TD may influence thresholds for referral. Closer collaboration between GPs and teledermatologists may improve GP knowledge and confidence in dermatology and improve referral accuracy.[50]

Cost effectiveness

Systematic reviews

One systematic review of economic studies comparing SAF TD for the triage of referrals to secondary care versus conventional face-to-face consultations was identified.[51] The systematic review incorporated 11 studies that examined SAF TD as a means of optimising referrals to dermatologists. Ten of the 11 studies involved GPs identifying patients as requiring a dermatology referral. In the remaining study patients with psoriasis sent information directly to their dermatologist. Dermatologists reviewed the images and responded by either scheduling a face-to-face appointment, giving guidance for GP management of the patient's condition, or concluding that no action was required. SAF TD was compared with a conventional care model of written referral to a dermatologist in which all patients attend a face-to-face appointment, the urgency of which is determined by the referral letter. The countries in which the studies were conducted included: United States (n=4), the Netherlands (n=2), Spain (n=2), United Kingdom (n=2), and New Zealand (n=1). Among the 11 studies, eight reported results from the perspective of their national healthcare system, national department of defense or the Department of Veterans Affairs. The three other studies described their analyses as being from a societal perspective, and also included costs incurred by healthcare institutions, the patient and the government. The overall evidence quality of each article was appraised using an abridged version of the rating system published by the Oxford Centre for Evidence-Based Medicine. The absence of best-practice reporting was assessed using the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) checklist, finding quality scores ranging from 7 to 21 (out of a possible 24 points), with a median score of 17.

The characteristics of the economic studies included in this systematic review are presented in *Table 3*.[51] Most studies, with the exception of those by Eminović et al[52] and Datta et al[53] who concluded equivalence, found SAF TD to be a cost effective use of resources. The type of economic evaluation conducted differed across studies: three studies adopted a cost effectiveness analysis (CEA) approach, expressing their outcome effect in terms of days to 'initial intervention'; two studies applied a cost-utility framework (CUA), estimating quality-adjusted life-years (QALY) and expressing outcomes as an incremental cost per QALY gained; the remaining studies were cost-minimisation analyses (CMA), which assumed, explicitly or implicitly, that no difference in health benefits exists between care models. Only two studies reported a time horizon for their analysis.[52, 53]

Table 3: Characteristics and results of included economic studies[51]

Source (Location)	Analysis Type	CHEERS Quality Score (max: 24 points)	Perspective	Cost of SAF TD per Patient	Outcome	SAF TD Concluded to be Cost effective?
Datta et al, 2015 (United States)	CUA/CMA	18	Department of Veterans Affairs and societal (individual costs only)	Saved US $30 (VA); saved US $82 (societal)	CMA performed due to equivalent utility; saved US $30 per patient (VA perspective) and US $82 per patient (societal perspective)	Equivalent (VA perspective); yes (societal perspective)
Eminović et al, 2010 (Netherlands)	CMA	21	Societal (individual costs only)	Saved €32.50 (US $35.32)	S&FTD has a 0.11 probability of being cost effective	Equivalent
Ferrándiz et al, 2008 (Spain)	CEA	18	Healthcare system	Saved €122.02 (US $132.59)	Saved €3.10 (US $3.37) per patient per day; increased to €4.87 (US $5.29) for patients who had impediments to travel	Yes
Lim et al, 2012 (New Zealand)	CMA	13	Healthcare system	Saved NZ$42 (US $28.10)	Saved NZ$42 (US $28.10) per patient	Yes
Livingstone & Solomon, 2015 (United Kingdom)	CEA/CMA	7	NHS	Saved £12 460 (total for all participants) (US $16.89)	Saved £12 460 (total for all participants)	Yes
Moreno-Ramírez et al, 2009 (Spain)	CEA	16	NR	Saved €49.59 (US $53.89)	Saved €0.65 (US $0.71) per patient per day	Yes
Morton et al, 2011 (United Kingdom)	CA	18	NHS	Saved £1.70 (US $2.39)	Saved £1.70 (US $2.39) per patient	Yes
Pak et al, 2009 (United States)	CMA	17	Department of Defense	Saved US $32	Saved US $32 per patient	Yes
Parsi et al, 2012 (United States)	CUA	21	Societal (institutional, individual and governmental costs)	Saved US $261	Mean improvement in QALYs was not significant between groups; S&FTD saved US $539.58 per QALY	Yes
van der Heijden et al, 2011 (Netherlands)	CMA	14	Healthcare system	Saved €34.94 (US $37.97)	Cost reduction estimated at 18% (average weighted costs)	Yes
Whited et al, 2003 (United States)	CEA	15	Department of Veterans Affairs	Saved US $15	Saved US $0.12 to $0.17 per patient per day	Yes

Abbreviations: CA = cost analysis; CEA = cost effectiveness analysis; CUA = cost-utility analysis; CMA = cost-minimisation analysis; CHEERS = Consolidated Health Economic Evaluation Reporting Standards; NR = not reported; VA = Veterans Affairs; SAF = store-and-forward; TD = teledermatology

Primary studies

The summary of primary studies includes six economic studies not included in the systematic review above. [23, 26, 54-57] Studies were conducted in, Spain (n=3), United Kingdom (n=1), Denmark (n=1), New Zealand (n=1), and Australia (n=1). Studies conducted in the United States and those that evaluated telemedicine as a single category across multiple medical specialties were excluded due to their limited applicability to NHSScotland.[58-60] The four cost analyses,[23, 26, 54, 56] a cost-minimisation analysis[55] and a CEA are described below.[57]

United Kingdom

The retrospective observational study conducted in London discussed above included a cost analysis.[23] The authors estimate that overall cost savings for the Clinical Commissioning Group over this time period (2017-2020) were £671,218. This was based on NHS National Tariff rates for 2019, which set the cost of TD appointment at £50 compared with £149 for an initial face-to-face consultation. The added cost of those patients (23.6%) who ultimately required a face-to-face consultation after their initial TD consultation was accounted for in this figure. The average cost saving for a TD appointment compared with face-to-face consultation per patient was £80.36. Cost savings in Trust overhead costs, after accounting for the cost of medical photographers, were estimated at £53,587. Overall savings for patients were estimated by accounting for travel time and time off work to attend their appointment. These were estimated assuming a return trip to hospital would take 60 minutes compared to 30 minutes to a local TD hub, and a weighted average annual income of £38,214 per person; based on these assumptions, overall savings for patients were estimated to be £51,943.

An approximate estimate of the carbon footprint with and without TD was also calculated. This was conducted by randomly selecting 60 TD patients and calculating the average distance of a return trip to attend Trust hospitals (11.2 miles) compared to TD clinics (6.4 miles). Informed by government data, 58.4% of cars in the United Kingdom were assumed to be petrol, 38.2% were diesel, with the remainder being a combination of hybrid/electric. In addition, a report by the London School of Economics found that 46% of London residents use public transport. It was further assumed that 5% of patients would walk or cycle, and the rest would use a car or taxi service. Based on these assumptions, the overall savings on carbon footprint was estimated to be 5 tonnes of CO_2 emissions over the study period.

European

A retrospective observational study at the Hospital de Poniente in Southern Spain compared the costs of SAF TD relative to conventional face-to-face monitoring (CM) from a societal perspective.[54] The TD care model required patients to attend a TD centre where nursing staff take images (including dermatoscopic) of the patient's lesions and upload these to a secure platform. Data were collected from 1 April 2019 to 30 March 2020, comprising 7,030 patients. 2,629 (38%) patients were ultimately sent for a face-to-face consultation with dermatologist. The remaining referrals were completed by the dermatologist after examining the images and the clinical report. 108 (1.54%) referrals required clarification by the GP, and two (0.03%) referrals were dismissed because of a software error. A per patient cost saving of 31.7% (£16.17 TD versus £23.66 CM; €18.59 TD versus €27.20 CM) for the national health system was estimated during this time period. Costs to the patients were found to be 73.5% lower (£4.74 TD versus £17.91 CM; €5.45 TD versus €20.58 CM).

Vestergaard et al conducted a cost-minimisation analysis comparing TD to conventional face-to-face appointments with a consultant dermatologist for patients with suspicious skin lesions in Southern Denmark.[55] Data were collected from 48 general practices, including 519 adult patients with 600 suspicious skin lesions over a 10-month period. Each practice was provided with an iPhone 6© (Apple Inc, Cupertino, CA, USA) and Handyscope© (FotoFinder Systems GmbH, Bad Birnbach, Germany) to enable macroscopic and dermascopic imaging. After photographing the lesion(s), GPs referred patients to the Department of Dermatology and Allergy at Odense University Hospital. The analysis accounted for four main types of cost: investment, GP-associated, hospital-associated and those incurred by the patient. Investment and GP-associated costs were found to increase and were only partially offset by a reduction in hospital-associated costs and costs to the patient, resulting in an overall cost of TD per patient that was £14.96-£20.10 (€17.20–€23.10) higher than that of standard care.

A cost analysis in Northern Spain compared TD with conventional face-to-face appointments with a consultant dermatologist for patients with suspicious skin lesions.[56] Data were collected from 14 general practices during 2016, accounting for 4,502 referrals. The analysis adopted a societal perspective, including direct costs to the national healthcare system and indirect costs to the patient. It was estimated that direct costs to the TD service for this period were £26,148 (€30,055), compared to £35,152 (€40,405) for standard care, representing a saving of £9,005 (€10,350). After accounting for indirect costs incurred by patients, overall savings were estimated to be £44,513 (€51,164) per year.

Non-European

Snoswell et al conducted a CEA comparing TD to traditional face-to-face appointments with a consultant dermatologist for skin cancer diagnosis and management in Australia using a 4-month time horizon.[57] This study analysed the costs and time (in days) to clinical resolution associated with each care model, defining clinical resolution as diagnosis by a dermatologist or excision of the lesion(s) by a GP, using a decision-analytic model. Results of the analysis found that the mean-average time to clinical resolution was 9 days (range: 1–50 days) with TD compared with 35 days (range: 0–138 days) with standard care (difference: 26 days; 95% credible interval [CrI]: 13–38 days). The estimated mean-average difference in the cost of TD (£181.48; A$318.39) and standard care (£150.34; A$263.75) was £31.15 (A$54.64) (95% CrI: £12.93–£55.49; A$22.69-A$97.35) per patient. The incremental cost per day saved to clinical resolution was £1.20 (A$2.10) (95% CrI: £0.50–£3.02; A$0.87-A$5.29). The authors conclude that use of TD for skin cancer referral and triage in Australia would cost an additional £31.15 (A$54.64) per case on average, but would result in clinical resolution 26 days earlier than standard care.

A cost analysis was conducted comparing TD to conventional face-to-face appointments with a consultant dermatologist for the diagnosis of melanoma in New Zealand.[26] A total of 613 skin lesions from 310 patients were evaluated over a period of one year. The median-average time from receipt of referral to attendance at the virtual clinic was 9 days compared

with 26.5 days for standard care; sixty-six percent (n=404/613) of lesions were considered benign and 12% (n=73/613) were suspicious for melanoma. A total of 129 lesions were excised, 98 of which were skin cancers including 48 that were histologically confirmed as melanomas with one spitzoid tumour of unknown malignant potential and 49 non-melanoma skin cancers. The analysis reported that TD was associated with a cost savings in excess of £185,640 (NZ$364,000) (£599 per patients; NZ$1,174 per patient).

Cost consequence analysis

A de novo cost consequence analysis was conducted to illustrate the potential economic benefits from an increased uptake of a SAF TD referral triage system across NHSScotland. The different sources of benefit accounted for in the analysis are as follows:

- monetary value of healthcare resources avoided,
- cash savings to patients due to a reduction in travel requirements, and
- decreased carbon emissions through a reduction in travel requirements for patients.

Healthcare resource use by referral system

The healthcare resources associated with conventional referral and SAF TD referral triage system are provided in *Table 4*. The type of resources used in each system was informed by an observational study conducted by Morton et al at NHS Forth Valley in Scotland for patients urgently referred on suspicion of skin cancer.[21]

For the purpose of the economic model, patients enter each system through a visit to their GP who initiates a referral to secondary care (that is, hospital-based dermatology services). Upon receipt of the referral, a consultant dermatologist remotely assesses the urgency of investigation or treatment required by the patient (that is, active clinical referral triage [ACRT]). The expected outcome following ACRT is assumed to differ by system, which reflects variation in practice with more informed decision-making by clinicians on account of having digital images in addition to a written referral.

The published literature indicates that between 47% and 54% of general population patients (ie excluding urgent or emergency cases) processed via a SAF TD referral triage system using simple digital photography can be safely managed in primary care.[16-18, 37] Similarly, when dermatoscopic images are used in addition to simple digital images, there is evidence that between 42% and 64% of patients with suspected skin cancer can be referred back to their GP for management in primary care.[21, 24-26] Based on this information, it is assumed that 50% of referrals to secondary care dermatology services are referred back to primary care when processed using a SAF TD referral system. No information was identified regarding the percentage of referrals that can be safely managed in primary care when processed using a

conventional referral system. It is assumed that only 10% of patients in a conventional referral system are referred back to their GP for management. For patients referred back to their GP in each system, it is assumed that 20% of patients require a telephone or face-to-face appointment with their GP to communicate the outcome of their referral. The remaining proportion of patients are assumed to receive the outcome of their referral via a letter sent to their home address.

Ninety percent of patients processed via the conventional referral system are assumed to require attendance at a consultant-led diagnostic clinic. For SAF TD patients, the 50% of patients processed using the SAF TD referral system can be managed as follows: referred directly to surgery, sent for photodynamic therapy, referred to another medical specialty, or allocated an appointment at a consultant- or nurse-led diagnostic clinic.[21]

Based on the two referral pathways and the proportions of patients assumed to be routed through each pathway, the proportion of patients using healthcare resources is presented in *Table 4*.

Table 4: Percentage of resource use associated with conventional referral and SAF TD referral triage pathways[21]

Healthcare resource use	Conventional Referral	Store-and-forward Teledermatology Referral
	% of patients	
GP visit	100.00%	100.00%
Photo upload (Band 6 Administrative Officer)	-	100.00%
ACRT	100.00%	100.00%
GP	**10.00%**	**50.00%**
Phone-call/appointment	2.00%	10.00%
Letter only	8.00%	40.00%
Consultant dermatologist appointment (diagnostic clinic)	**90.00%**	**14.20%**
Nurse-led clinic	**-**	**20.95%**
Direct to surgical list	**-**	**10.90%**
Direct to PDT	**-**	**1.55%**
Community GP special interest clinic (diagnostic clinic)	**-**	**1.20%**
Direct to another specialty	**-**	**1.20%**

Abbreviations: GP = general practitioner; ACRT = Active Clinical Referral Triage; PDT = photodynamic therapy

Baseline use of SAF TD referral system by health board

The estimated proportion of primary care referrals to secondary care dermatology services that include digital images, by health board, at present is shown in *Table 5* and ranges from 10-80%. The figures are inferred from data collected via interviews with senior clinicians and are used to proxy the relative usage of each referral system by health board (Mr J Cochrane, Head of Programmes, National Centre for Sustainable Delivery. Personal Communication, 05/10/222). This information is used in the analysis to adjust the estimated benefits reported in the results section for current usage of each referral system in each health board.

Table 5: Estimated proportion of referrals including digital images by health board

Health board	Proportion of referrals with image attached
NHS Ayrshire & Arran	50%
NHS Borders	25%
NHS Dumfries & Galloway	50%
NHS Fife	40%
NHS Forth Valley	20%
NHS Grampian	50%
NHS Greater Glasgow & Clyde	50%
NHS Highland	30%
NHS Lanarkshire	10%
NHS Lothian	10%
NHS Orkney	30%
NHS Shetland	30%
NHS Tayside	80%
NHS Western Isles	30%

Quantity of resources, unit costs and total costs

Resource use, unit costs, and total costs incurred have been outlined from the perspective of the healthcare system and the patients that are accounted for in the analysis.

Healthcare system perspective

The quantity of time required to carry out specific tasks and the unit cost of each healthcare professional's time used is shown in *Table 6*. The time (in minutes) for each task was assumed to be consistent with that reported by Morton et al in their observational study conducted at NHS Forth Valley in Scotland.[21] The unit costs for each healthcare professional (per hour of time) were sourced from the Personal and Social Services Research Unit report on the *Unit Costs of Health and Social Care 2021*.[61]

Table 6: Resource use, unit costs, and total costs[21, 61]

Service and associated costs	Time (minutes)	Unit Cost (£ per hour)	Total Cost (£)
		2020/2021	
GP visit	9	184.00	27.60
Photo upload (AfC band 6)	5	53.55	4.46
Total cost	**NA**	**NA**	**32.06**
ACRT			
Photo-triage (consultant)	1	123.00	2.05
Appointment allocation (AfC band 4)	5	34.92	2.91
Total cost	**NA**	**NA**	**4.96**
Consultant diagnostic clinic			
Patient notes to clinic (consultant)	1	123.00	2.05
Clinic time (consultant)	10	123.00	20.50
Clinic letter (consultant)	2	123.00	4.10
Clinic letter (AfC band 4)	5	34.92	2.91
Total cost	**NA**	**NA**	**29.56**
Nurse clinic			
Patient notes to clinic (AfC band 7)	1	62.00	1.03
Clinic time (AfC band 7)	10	62.00	10.33
Clinic letter (AfC band 7)	2	62.00	2.07
Clinic letter (AfC band 4)	5	34.92	2.91
Total cost	**NA**	**NA**	**16.34**
Community GP special interest clinic	9	217.00	32.55

Abbreviations: GP = general practitioner; ACRT = active clinical referral triage

Patient and societal perspective

The weighted average cost of travel required to attend a face-to-face consultation at hospital, by health board, used in the analysis is provided in *Table 7*. Data on the mode of transport (for example, car, bus, train) and average distance travelled to work by individuals in each health board area reported in the 2011 census for Scotland was used to proxy transport method to hospital for patients.[62] The cost per unit of distance travelled for each mode of transport was informed by reference to national data on the cost of different modes of transport.[63]

The weighted average carbon (tonnes of CO_2e) emitted by attending a face-to-face consultation at hospital, by health board, used in the analysis is also provided in *Table 7*. These figures were estimated by combining data on the mode of transport and distance travelled to work from the 2011 census for Scotland with data on the average carbon emitted per unit of distance for each mode of transport.[62, 64]

Table 7: Weighted average travel cost for trip to hospital[62, 63]

Health board	Weighted average travel cost (£)	Weighted average carbon (tonnes of CO_2e)
NHS Ayrshire & Arran	4.66	0.00169
NHS Borders	2.79	0.00166
NHS Dumfries & Galloway	2.79	0.00166
NHS Fife	3.93	0.00165
NHS Forth Valley	3.50	0.00176
NHS Grampian	3.01	0.00171
NHS Greater Glasgow & Clyde	5.73	0.00121
NHS Highland	5.73	0.00121
NHS Lanarkshire	4.76	0.00163
NHS Lothian	4.01	0.00149
NHS Orkney	2.50	0.00163
NHS Shetland	2.73	0.00173
NHS Tayside	3.67	0.00142
NHS Western Isles	2.73	0.00173

Total number of additions to dermatology waiting lists

The total number of additions to dermatology waiting lists, by health board, for the years between 2019 and 2022 (based on a year-end date of 30th October) are provided in *Table 8*. These figures were calculated based on data provided by Public Health Scotland and are used to proxy the number of referrals from primary care to secondary care dermatology services (Mr J Donaghy, Senior Information Analyst, Public Health Scotland. Personal Communication, 28/11/22). Data on the number of referrals from primary care to secondary care dermatology services are not currently collected by Public Health Scotland. It is therefore possible that the figures reported in *Table 8* include referrals for patients who are receiving ongoing treatment or monitoring for their condition, leading to an over estimate of the number of diagnostic referrals from primary care per year.

Table 8: Total additions to dermatology waiting lists

Health Board	Total number of additions to the waiting list		
	2019/2020	2020/2021	2021/2022
NHS Ayrshire & Arran	5,680	6,017	6,432
NHS Borders	2,040	2,400	2,756
NHS Dumfries & Galloway	2,944	3,590	3,681
NHS Fife	6,327	7,817	9,152
NHS Forth Valley	5,332	7,105	8,229
NHS Grampian	8,360	11,127	12,459
NHS Greater Glasgow & Clyde	31,737	37,983	41,839
NHS Highland	3,738	4,522	5,253
NHS Lanarkshire	11,165	12,471	13,289

NHS Lothian	16,865	16,438	15,706
NHS Orkney	394	515	402
NHS Shetland	29	69	247
NHS Tayside	7,111	7,641	8,754
NHS Western Isles	361	466	579
Total	**102,083**	**118,161**	**128,778**

Results

The estimated results in terms of the monetary value of healthcare resources avoided, cash savings to patients due to a reduction in travel requirements, and the decrease in carbon emissions through a reduction in travel requirements for patients are shown in *Table 9*.

Table 9: Base case and sensitivity analysis results

Scenario	Description		2019/2020	2020/2021	2021/2022
Total Value (£) of Healthcare Resource Avoided					
0	Proportion of referrals that include digital images	75% (base case)	459k	521k	558k
1		50%	177k	192k	202k
2		100%	758k	867k	936k
Patient Savings (£)					
0	Proportion of referrals that include digital images	75% (base case)	34k	41k	44k
1		50%	13k	15k	16k
2		100%	57k	68k	73k
Decrease in Carbon Emissions (tonnes of CO2e)					
0	Proportion of referrals that include digital images	75% (base case)	23.25	29.70	31.84
1		50%	9.29	10.97	11.50
2		100%	38.02	49.47	53.37

Discussion

De novo cost consequence analysis has shown that increased uptake of a SAF TD referral triage system would lead to a reduction in healthcare resources, valued at between £459k and £558k per year assuming a similar volume of referrals as observed during the previous three years. Increased uptake of the SAF TD system is expected to save the patient population between £34k and £44k through a reduction in travel requirements by avoiding unnecessary outpatient appointments at hospital, and, in addition, lead to a reduction in carbon emissions of between 23.25 and 31.84 tonnes of CO2e.

This analysis is associated with a number of limitations that should be considered when interpreting these results.

- Assumptions regarding the healthcare resource use associated with conventional and SAF TD referral systems are based on evidencefrom the published literature.[16-18, 21, 24-26, 37] These data were primarily collected within patient populations referred on suspicion of skin cancer and used dermatoscopic images to triage referrals in addition to simple digital images.[21, 24-26] If the proposals for NHSScotland are to use SAF TD for all referrals to dermatology services and to use simple digital images only (that is, images captured via a phone camera) then it is unclear if the data used to inform these assumptions of healthcare resource use generalise to the proposals for NHSScotland.
- Baseline usage of SAF TD referral systems by health board was based on the experience of a limited number of senior clinicians and was noted to be highly uncertain. If baseline use of SAF TD referral triage systems across NHSScotland is higher than that assumed in the analysis, this could lead to an over estimate of the potential benefits associated with its increased uptake.
- Data on the total number of additions to dermatology waiting lists by year were used to proxy the number of referrals from primary care. It is possible that these data include referrals for patients receiving ongoing treatment or monitoring for existing conditions, thereby over estimating the number of diagnostic referrals from primary care. This may lead to an over estimate of the potential benefits associated with increased uptake.

Conclusion

Published studies on SAF TD for the triage of referrals demonstrate a reduction in waiting times for secondary care dermatology consultations through prevention of unnecessary appointments and by increasing the number of patients with skin problems who can be safely treated in primary care. Further benefits associated with SAF TD include an ability to more accurately prioritise referrals, resulting in patients with skin cancers being treated more quickly and at an earlier clinical stage than with conventional referral processes. There was an absence of evidence on the potential for an increase in missed or delayed diagnosis that may result from fewer face-to-face consultations.

Economic studies in the published literature reported that SAF TD for triage purposes is cost saving relative to conventional face-to-face care models. The majority of applicable clinical and economic studies included in this assessment were focused on lesions suspicious of skin cancer and used dermatoscopic images in addition to clinical images. The applicability of their findings to TD triage when applied to all dermatology referrals without necessitating dermatoscopic images, as is proposed across NHSScotland, is therefore uncertain.

A de novo cost consequence analysis for NHSScotland estimated that increased uptake of a SAF TD referral triage system would likely lead to a reduction in healthcare resource use and reduce travel requirements for patients, leading to decreased carbon emissions.

Identified research gaps

Comparative studies are required examining the clinical, system and health economic effects of TD triage of unselected primary care referrals for both adults and children. There is a need for high quality safety outcome data relating to the potential for missed or delayed cancer diagnoses and for data on the equality impact(s) of teledermatology triage.

Equality and diversity

SHTG advice takes into account equalities considerations across three key stages of the health technology assessment process:

- Topic / technology scoping
- HTA product development stage
- Development of recommendations/key findings.

The outcome of equalities considerations are incorporated within our HTAs. Equalities considerations take into account protected characteristics, additional characteristics and other groups in the population who may experience poor health due to external factors. Whether such groups can be identified depends on the topic and the evidence available.

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Appendix 1: abbreviations

AI	Artificial intelligence
ANIA	Accelerated National Innovation Adoption
BCC	Basal cell carcinoma
CEA	Cost effectiveness analysis
CHEERS	Consolidated health economic evaluation reporting standards
CMA	Cost-minimisation analysis
CO_2e	Carbon dioxide equivalent
CUA	Cost-utility framework
FBSE	Full body skin examination
GP	General practitioner
MM	Malignant melanoma
NHS	National Health Service
PCP	Photo capture and pass-through
QALY	Quality adjusted life year
RCT	Randomised controlled trial
SAF	Store-and-forward
SCC	Squamous cell carcinoma
TD	Teledermatology
TDSc	Teledermatoscopy
UK	United Kingdom
US	United States
VA	Veterans Affairs

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