East Midlands Academic Health Science Network
Igniting Innovation

EDGE

An evaluation of AI Powered Tele Dermatology for Skin Cancer 2WW Pathway

October 2023

Contents

1. Executive Summary

Dermatology services across England and Wales are experiencing an extraordinary degree of strain due to the current demand surge with one in four individuals seeking consultation for skin, hair, or nail conditions each year. The COVID-19 pandemic caused approximately 30% fewer dermatology appointments during 2020/21 compared to the previous year. The post-pandemic influx of patient referrals continues to pose substantial challenges to health systems grappling with an increased patient load, rising case complexities, and often diminished staff numbers.

Against this backdrop, the necessity for innovative solutions to enhance patient access to dermatology services has been acknowledged by several national and professional entities. Teledermatology, especially, has been widely endorsed as an effective method to expand service capacity and ensure equitable patient access to specialist care. An alternative is AI-Powered Teledermatology, which utilises AI technology for initial skin lesion assessment.

In March 2022, a Skin Analytics AI-Powered Teledermatology for Skin Cancer 2WW Pathway was pilot tested across University Hospitals of Leicester (UHL) sites. This pilot initiative was a collaborative project involving the UHL Dermatology Service, Leicester, Leicestershire and Rutland (LLR) Elective Care Team, UHL Cancer Centre and UHL Alliance, and was designed to respond to the local need for improved patient access to dermatology diagnostics and the achievement of 2-week-wait (2WW) cancer targets.

Our evaluation of the pilot's effectiveness uses both qualitative and quantitative data, gathered through staff and patient surveys and existing data from UHL and Skin Analytics. Our findings suggest the pilot demonstrated the capability of AI-powered teledermatology, but it was unable to deliver significant savings relative to its cost (benefit cost-ratio of 1.05). It is important to note that there are a number of benefits which were not possible to quantify as part of the pilot and scenario analysis, including a reduction in biopsies, a reduction in longer-term care costs, and a reduction in WLI clinics. Further to this, contractual challenges were noted, which should prompt local monitoring of true expenditure and remuneration.

Additionally, the evaluation found an increase in the length patients spend on the pathway when on an AI-powered teledermatology pathway compared to standard of care. This has been linked to administrative delays in appointment scheduling and not an issue with the technology.

Looking forward, we conducted scenario modelling to explore the potential for greater savings in the future in view of an updated pricing model for the AI pathway, which hinge on reducing or removing the cost associated with the second read. These scenarios deliver a benefit-cost ratio ranging from 1.27 to 1.88 contingent on who undertakes the remote second reading of dermoscopy images, which would require a thorough local assessment to decide whether the second read should be removed or not.

Although some challenges remain with implementation and staff acceptability of the current model of delivery, there is the potential for this novel pathway to be cost-effective in the long-term and enable considerable benefits that encompass the wider Dermatology cohort, UHL staff and the health system. We propose several recommendations to enhance the programme's benefits and ensure the longer-term cost-effectiveness is achieved. These include rectifying administrative delays in appointment scheduling and internally evaluating the best option for lesion second reads. Further evaluations should be conducted as the AI versions improved and more data becomes available.

2. Overview of Dermatology Services at University Hospitals Leicester

Section summary

Key insights from this section:

- Demand for dermatology services is increasing around University Hospitals Leicester and nationally.
- Workforce numbers are also increasing, but this trend fails to account for increasing number of posts filled by locum staff, increasing caseload complexity and a long-standing inability to fill consultant posts to meet staffing recommendations.

2.1. Introduction

Dermatology is an essential branch of medicine that focuses on the diagnosis and treatment of skin, nail, and hair conditions. Demand for Dermatology is high across the country and the demand for suspected skin cancer referrals has seen a steady increase. Each year, Dermatology services receive more urgent referrals for suspected cancer than any other specialty[1]. The dermatology department at University Hospitals of Leicester (UHL) plays a vital role as the main secondary care provider for the local population of 950,000, and the only recognised provider of specialist dermatology services within the East Midlands. The department is also a major teaching centre, making it an essential hub for the development of future healthcare professionals.

2.2. The rising volume of suspected cancer referrals

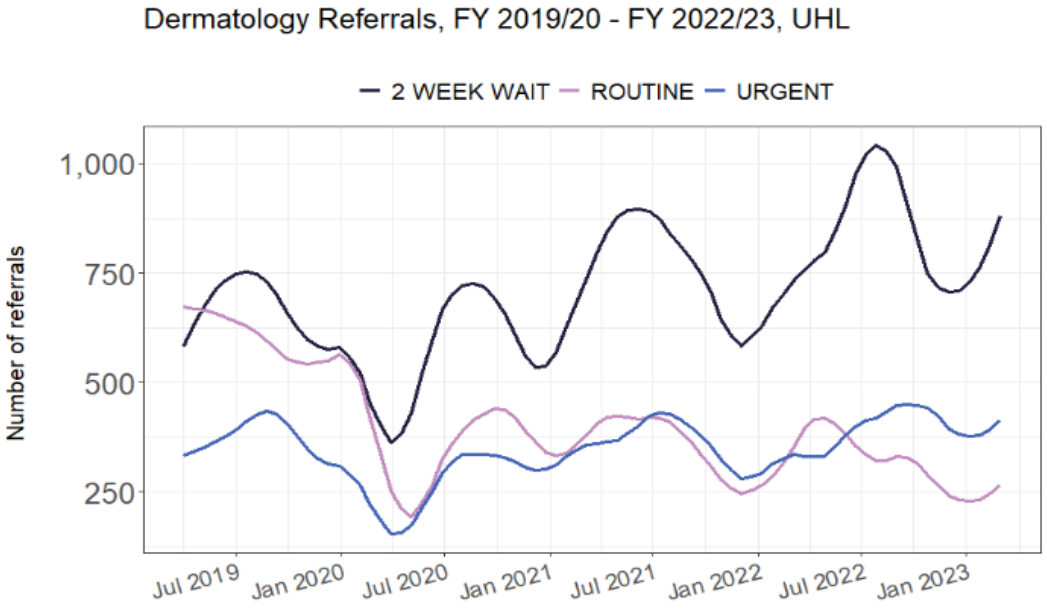
Nearly 50% of the Dermatology referrals received across the NHS Leicester, Leicestershire and Rutland (LLR) Integrated Care Board (ICB) are for suspected cancer[2] and classed as “two-week-wait” (2WW) (Figure 1). In Financial Year 2022/23, this amounted to approximately 10,000 referrals at UHL and is part of a steadily increasing demand trend. The increase in 2WW referrals compared to 2018 is also significantly higher than the national average, at 37% (UHL) versus 13% (England average).

The increased volume of referrals for 2WW skin cancer has been adding a further challenge to an already strained system. The COVID-19 pandemic led to 30% fewer Dermatology appointments in 2020/21 compared to the previous year, resulting in a significant unmet need.

[1] NHS eRS Open Data dashboard

[2] NHS Digital, NHS e-Referral Service Open Data

Figure 1 Number of dermatology referrals received by UHL Dermatology department between FY 2019/20 and FY 2022/23, by type of referral (2 week wait, routine or urgent). *Note that the seasonal fluctuation in referrals for suspected skin cancer is a well-documented[3] phenomenon that will not be discussed here.*



2.3. Effects on cancer patients care and outcomes

At UHL, the situation has been particularly challenging, with a sharp increase in breaches for cancer waiting times, and 28% of patients not being seen within the 2WW target in 2021/22 compared to 5% in 2019/20. In addition, 40% of patients missed their 62-day target in 2021/22 compared to 4% in 2019/20, and the volume of incoming referrals has steadily increased from an average of approximately 600 per month to more than 800 per month in 2022/23.

2.4. National workforce challenges

In addition to the outlined pressures of increased service need and rising patient complexity, workforce shortages amongst Dermatology consultants have been mounting for a number of years. The 2021 GIRFT Dermatology report[4] highlighted that 24% of all Dermatology consultant posts were vacant, with 508 whole-time-equivalents (WTE) consultants employed and 159 unfilled WTEs.

As a result of the report, a number of recommendations were put forward to address workforce shortages, which included a wider-spread use of technology, including teledermatology.

Although there has been a steady increase in Dermatology consultant WTE counts over the last 15 years (Figure 2), these trends fail to take into account:

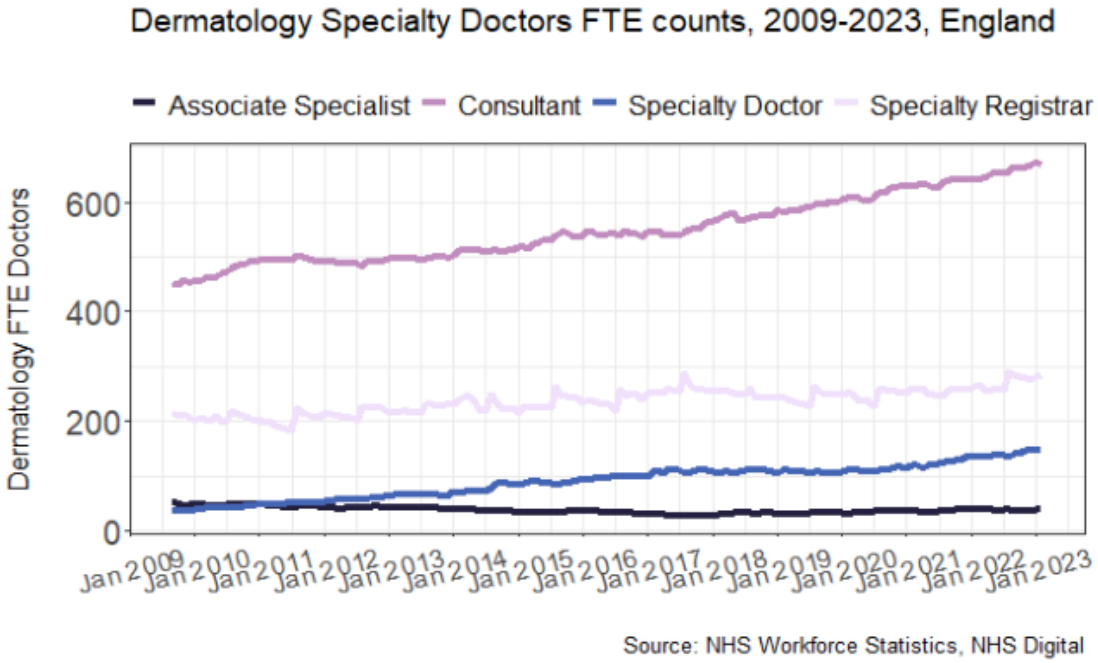
- The number of posts filled through appointing Locum consultants (at the time of the GIRFT report, this was, on average, 30% of filled positions);

[3] Walter FM, Abel GA, Lyratzopoulos G, Melia J, Greenberg D, Brewster DH, Butler H, Corrie PG, Campbell C. Seasonal variation in diagnosis of invasive cutaneous melanoma in Eastern England and Scotland. Cancer Epidemiol. 2015 Aug;39(4):554-61.

[4] GIRFT. Dermatology Report. Sept 2021.

- The changing mix of the Dermatology caseload that has increasingly shifted towards more complex patients such as skin cancer, who require more treatment and diagnostic capacity than others[5];
- The long-standing inability to fill consultancy posts to meet the Royal College of Physicians (RCP) staffing recommendations of one WTE per 300,000 population[6].

Figure 2 Trend of Dermatology consultant WTE (whole-time-equivalent) counts in England, between 2009 and 2023.



All of the above are less straightforward to capture within data, but nevertheless have material impacts on Dermatology waiting lists and workload, and individual trusts' ability to fill Dermatology consultant posts.

[5] Eedy D. Dermatology: a specialty in crisis. Clin Med (Lond). 2015 Dec;15(6):509-10. 10.7861/clinmedicine.15-6-509..

[6] Royal College of Physicians Dermatology. London: RCP, 2013.

3. Existing Research and Evidence on the use of AI-Powered Teledermatology

Section summary

Key insights from this section:

- Existing and current research and publicly available evidence highlights many of the potential benefits from AI-powered Teledermatology for staff, patients, health systems, and more generally (e.g., for net-zero).
- There are also limitations published in the literature, including concerns on healthcare disparities a lack of real-world evidence on some of the costs and challenges with developing, deploying and integrating AI-Teledermatology into existing health system pathways and changing patient perceptions.

3.1. Introduction

Teledermatology – the use of electronic tools for remote consultations in Dermatology – has been growing in popularity and usage, particularly following the COVID-19 pandemic. The emergence of Artificial Intelligence (AI) in this field is transforming the way dermatology services are delivered, enhancing patient care, and significantly improving healthcare processes, as new tools harness the ability of AI to analyse dermatological images to support clinical decision-making.

The benefits of traditional teledermatology include improved access to care, quicker diagnosis, and better utilisation of resources. The addition of AI in teledermatology can further optimise these benefits, with AI algorithms assisting in the efficient triage and diagnosis of skin lesions. Furthermore, these algorithms enable quicker and more accurate reviews of images, making the whole process significantly more efficient.

Over the recent years, several national publications from NSHE and professional bodies have publicly acknowledged the need for digital solutions in Dermatology to enhance or transform traditional pathways[7,8,9,10], in view of a number of recognised benefits. Some limitations, however, remain to its use and should be considered when making implementation considerations.

3.1. Benefits to Staff

3.1.1. Use of clinical time

The first notable benefit of AI-powered teledermatology for staff is that it enables significant clinical time savings. The review of remote dermoscopy images averaged 75 seconds at Leeds Teaching Hospitals NHS Trust[11], compared to an average of 12-minutes per face-to-face appointment. Considerably more urgent patients can be reviewed within the same amount of time, which is of benefit to both patients who undergo AI-teledermatology, as well as the wider waiting list.

[7] NHSE Transformation Directorate Dermatology Digital Playbook
[8] NHSE 2023/24 Priorities and Operational Planning Guidance, Jan 2023
[9] NHSE Referral optimisation for people with skin conditions, Sept 2022
[10] A teledermatology roadmap. Implementing safe and effective teledermatology triage pathways and processes. NHS England. July 2023. Version 2.
[11] NHSX Dermatology Digital Playbook, Leeds Teaching Hospital NHS Trust

The effective triage allowed by AI-teledermatology means that Dermatologists' time and expertise is effectively utilised where it is needed the most, such as for patients where the potential for a lesion to be cancerous is more likely[12]. A long-term review of UK Teledermatology services found that up to 50% of GP referrals could be discharged with advice, while 14% could be enlisted directly for surgery, significantly focusing consultant Dermatologists efforts during face-to-face clinics in reviewing only the patients who would benefit most[13].

3.1.2. Improved diagnostic accuracy

Additionally, AI offers a new tool for healthcare staff to improve their diagnostic accuracy. A meta-analysis of 70 studies found the accuracy of computer-aided diagnosis of melanoma to be comparable to that of human experts (AUROC of clinicians reported at 90.8%, versus algorithm at 92.3%[14]). This enables significant benefits, particularly when AI-teledermatology is employed in primary care, as it can support non-specialist clinician's diagnostic process[15].

3.2. Benefits to Patients

3.2.1. Faster diagnosis

AI-teledermatology has the potential to significantly speed up diagnostics, thereby reducing patient anxiety during the waiting period. An AI-powered 2WW pathway at West Suffolk NHS Foundation Trust (WSFT) significantly improved the number of 2WW referrals that are seen within target times[16]. AI performance in diagnosis of melanoma and non-melanoma skin cancer has also shown no significant difference from board-certified dermatologists, providing reassurance towards its safety[17,18].

3.2.2. Reduction in unnecessary hospital visits and procedures

When AI-teledermatology is implemented either in primary care, in the community settings or at sites close to the patient's home, this helps reduce unnecessary travel to hospital[19]. This is especially beneficial for those living in remote areas or those with mobility issues.

Teledermatology implemented at Chelsea and Westminster Hospital concluded that the teledermatology service allowed a 15% reduction in the number of patients undergoing a biopsy[20].

[12] Giansanti D. The Artificial Intelligence in Teledermatology: A Narrative Review on Opportunities, Perspectives, and Bottlenecks. Int J Environ Res Public Health. 2023 May 12;20(10):5810

[13] Mehrtens, S.H., Shall, L. and Halpern, S.M. (2019), A 14-year review of a UK teledermatology service: experience of over 40 000 teleconsultations. Clin Exp Dermatol, 44: 874-881.

[14] Phillips, M. et al. Assessment of Accuracy of an Artificial Intelligence Algorithm to Detect Melanoma in Images of Skin Lesions. *JAMA Network Open*. 2019. 2(10):e1913436.

[15] Chen SC, Pennie ML, Kolm P, et al. Diagnosing and managing cutaneous pigmented lesions: primary care physicians versus dermatologists. J Gen Intern Med. 2006;21(7):678-682.

[16] Skin Analytics. Response to the British Association of Dermatologists Letter, 2022 Dec

[17] Majidian M, Tejani I, Jarmain T, Kellett L, Moy R. Artificial Intelligence in the Evaluation of Telemedicine Dermatology Patients. J Drugs Dermatol. 2022 Feb 1;21(2):191-194.

[18] Jenkins R. et al. BT09 Clinical performance of an artificial intelligence-based medical device deployed within an urgent suspected skin cancer pathway. British Journal of Dermatology. 2023.

[19] NHS, British Association of Dermatologists. The two-week wait skin cancer pathway: innovative approaches to support early diagnosis of skin cancer as part of the NHS COVID-19 recovery plan. 2023 April.

[20] The British Association of Dermatologists: Outpatient Case studies, 2019

This provides benefits to the health system, reducing both capacity and funds required to support biopsies, as well as to patients, minimising the discomfort and the distress associated with biopsies.

3.3. Benefits to the Health System

In the context of rising volumes of 2WW referrals, and skin cancer in general, teledermatology solutions have been advocated for centrally to both reduce needless hospital attendances[8] and meet rising demands despite workforce shortages[21].

3.3.1. Earlier cancer detection, cost savings and patient satisfaction

A comprehensive review of current evidence for the use of AI-teledermatology highlighted several potential benefits for the addition of AI to these technologies. For instance, AI solutions have the potential to enhance and be complementary to human decision-making, thereby improving the rate of cancers detected at an early stage. Moreover, they are associated with cost savings – including the avoidance of unnecessary procedures, as discussed in section 4.2.3 – and improved healthcare processes, ultimately leading to increased patient satisfaction[4].

3.3.2. Relief for workforce shortages

Teledermatology, particularly AI-assisted teledermatology has the potential to provide significant relief to the current workforce shortages. The teledermatology-only pilot conducted at Leeds Teaching Hospital NHS Trust demonstrated a significant time-saving for consultants' clinical input[10]. Besides providing a benefit to staff, as previously discussed, cumulative time savings may eventually translate in a relief of demand pressures that would traditionally require hiring more staff.

In addition to this, use of teledermatology as described at Luton and Dunstable University Hospital[18] showed that the service was not only able to cope with rising volumes of 2WW referrals for suspected skin cancer, but also that 100% of cases had been seen within an NHS substantive dermatology consultant run service, reducing the Trust's reliance on locum consultants. This led to a cumulative savings of £40,000 during the pilot period.

3.3.3. Carbon Reduction and Net Zero

It is estimated that the NHS accounts for 5% of all road traffic in England, causing increased pollution and road traffic accidents. Reduced patient travel and enabling care closer to home has benefits the environment by reducing the NHS' carbon footprint.

Where a remote review leads to discharge without a F2F outpatient appointment (OPA), teledermatology has the potential to reduce the number of onward hospital attendances by patients[22]. By eliminating the need for transportation to these appointments, it can significantly reduce the carbon emissions associated with travel, with carbon footprint savings ranging between 0.70-372 kg CO2 per consultation[23]. In instances where patients are seen within community hubs rather than in General Practices prior to remote review, these are often closer to the patients' home and therefore reduce the travel time by car or even allow patients to walk to appointments.

[21] GIRFT recommendations address dermatology workforce shortages and call for wider use of technology. 2021 Nov

[22] NHS, British Association of Dermatologists. The two-week wait skin cancer pathway: innovative approaches to support early diagnosis of skin cancer as part of the NHS COVID-19 recovery plan. 2023 April.

[23] Purohit et al., Does telemedicine reduce the carbon footprint of healthcare? A systematic review, Future Healthc J, 8(1): e85–e91, March 2021

3.4. Limitations

3.4.1. Impact on healthcare disparities

As only a minority of skin cancers (<0.5%) are diagnosed in Black and Asian patients[24], algorithms have been trained primarily on European or East Asian populations, and concerns have been raised that this may exacerbate existing healthcare disparities[25]. The relatively low skin cancer incidence in higher Fitzpatrick skin types presents a challenge for statistically evaluating diagnostic accuracy and has been recognised as limitations in current studies[26]. Further to this, concerns on access to the technology and adoption by different socioeconomic groups raises implications for equality of care. Secondary and primary care models of AI-teledermatology are less likely to incur in these issues compared to patient-initiated teledermatology, but it remains that the issue of equity in AI and diagnostic accuracy needs to be carefully considered given the challenges with incidence.

3.4.2. Relative lack of real-world evidence

Although the role of AI for dermatology has been extensively researched in experimental settings in recent years, its use in a clinical setting outside of research is a relatively recent addition[27], with DERM being the first tool to be implemented in 2020. Although studies have shown promising results, there is currently only one AI-teledermatology tool that is approved for clinical use in the UK, meaning that evidence for practicalities on implementation, costs and benefits and long-term outcomes is still in development[28].

3.4.3. Changing patient perceptions

AI advancements in clinical medicine are progressing at rapid pace, and need to gain the favour of patients who are yet to become accustomed to the use of technology in healthcare. Studies on patients' perception of AI in dermatology have demonstrated a largely receptive population[29,30], though opinions remain mixed, particularly with regards to the extent of direct contacts with clinicians. The changing perceptions of AI with patients and staff alike pose opportunities as well as challenges to the implementation of AI technologies, and considerations should be given to the nature and extent of the information provided to both staff and patients, and to opportunities for patients to preserve their autonomy.

---

[24] Delon, C., Brown, K.F., Payne, N.W.S. et al. Differences in cancer incidence by broad ethnic group in England, 2013–2017. Br J Cancer 126, 1765–1773 (2022).

[25] Adamson AS, Smith A. Machine Learning and Health Care Disparities in Dermatology. JAMA Dermatol. 2018;154(11):1247–1248.

[26] Jain A, Way D, Gupta V, et al. Development and Assessment of an Artificial Intelligence–Based Tool for Skin Condition Diagnosis by Primary Care Physicians and Nurse Practitioners in Teledermatology Practices. JAMA Netw Open. 2021;4(4):e217249.

[27] Young AT, Xiong M, Pfau J, Keiser MJ, Wei ML. Artificial Intelligence in Dermatology: A Primer. J Invest Dermatol. 2020 Aug;140(8):1504-1512.

[28] Dilraj Kalsi, Lucy Thomas, Chris Hyde et al. Real-world post-deployment performance of a novel machine learning-based digital health technology for skin lesion assessment and suggestions for post-market surveillance, 27 April 2023, PREPRINT (Version 1) available at Research Square

[29] Nelson CA, Pérez-Chada LM, Creadore A, Li SJ, Lo K, Manjaly P, Pournamdari AB, Tkachenko E, Barbieri JS, Ko JM, Menon AV, Hartman RI, Mostaghimi A. Patient Perspectives on the Use of Artificial Intelligence for Skin Cancer Screening: A Qualitative Study. JAMA Dermatol. 2020 May 1;156(5):501-512.

[30] Lim K, Neal-Smith G, Mitchell C, Xerri J, Chuanromanee P. Perceptions of the use of artificial intelligence in the diagnosis of skin cancer: an outpatient survey. Clin Exp Dermatol. 2022 Mar;47(3):542-546.

4. Pilot Overview

Section summary

Key insights from this section:

- Skin Analytics is a Class IIa UKCA Mark AI-powered Teledermatology solution that provides both technology to assess photographs of suspect skin lesions and an additional human service for reviewing the initial results from the AI.
- Skin Analytics AI-powered Teledermatology solution was rolled out for UHL in early 2022 across a range of sites.

4.1. Background to Skin Analytics Teledermatology

Skin Analytics are the provider of DERM (short for Deep Ensemble for the Recognition of Malignancy), a Class IIa UKCA Mark AI software that has been trained to assess skin lesions and determine suspected diagnosis including the most common malignant, pre-malignant and benign conditions. DERM is able to evaluate lesion morphology providing a granular assessment of malignant, pre-cancerous and benign lesions, as follows:

- Melanoma
- Squamous Cell Carcinoma (SCC)
- Basal Cell Carcinoma (BCC)
- Bowen's Disease (IEC)
- Malignant 'Other'
- Actinic Keratosis (AK)
- Atypical Nevus
- Vascular Lesions
- Seborrheic Keratosis
- Solar Lentigo
- Melanocytic Nevus
- Dermatofibroma
- Benign 'Other'

Skin Analytics have been operating within the NHS since 2020, with University Hospitals Birmingham (UHB) being the first trust to pilot an AI-powered teledermatology service during the pandemic. Since then, they have expanded to provide support for twelve care providers, across primary and secondary care.

There are multiple care models that have been trialled by Skin Analytics for teledermatology in secondary care, though the traditional pathway begins following referrals from GPs for suspected skin cancer.

4.2. The Pilot across UHL

The AI-teledermatology pilot at UHL launched in March 2022 with the first Community Hub set-up at Loughborough Hospital. Through this pathway, patients referred by their GP with a suspicious skin lesion receive an invitation to attend the Community Hub to have a photograph taken. At the Community Hub, a trained staff member collects at least three photographs of the skin lesion, one through a dermoscope mounted on an iPhone camera which is analysed by DERM and two or more through the standard phone camera to indicate lesion location. Photos are submitted to the Skin Analytics platform for review by the AI software as well as the Skin Analytics or UHL dermatologists.

Patients who meet the following criteria are not suitable for teledermatology assessment, and follow the traditional 2WW referral pathway:

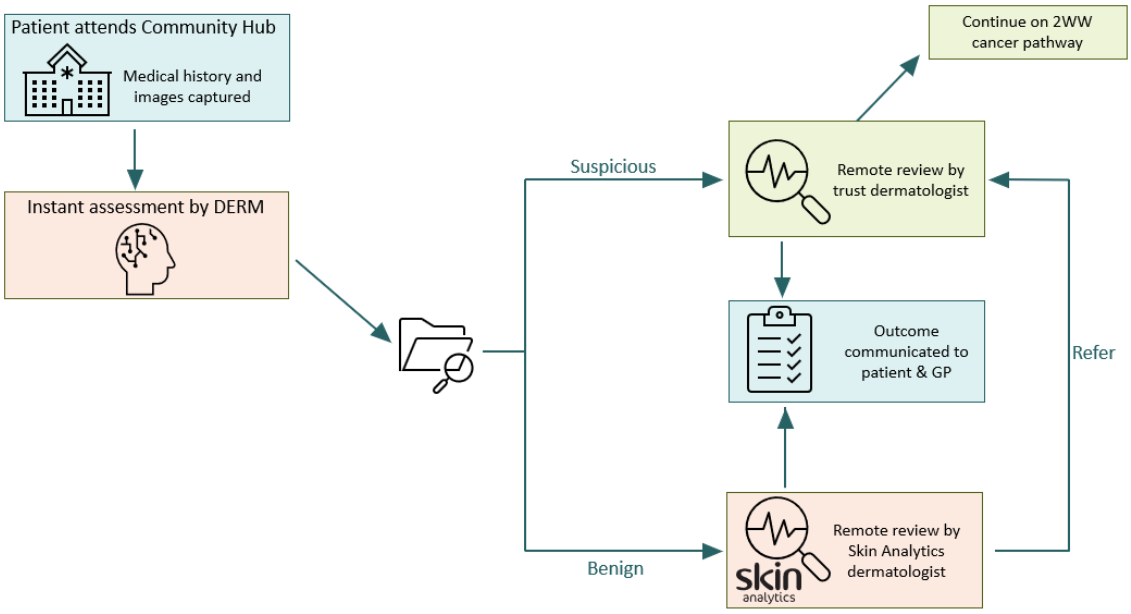
- Under 18 years of age
- With multiple (more than 2) suspicious skin lesions
- With genital lesions

4.2.1. Pathway Design

To address the growing waiting lists and workforce constraints, UHL has partnered with Skin Analytics (SA) to pilot an AI-powered teledermatology for 2WW skin cancer pathway since March 2022 (Figure 3). Patients who are referred from GPs attend one of four clinical hubs (Loughborough Hospital, Melton Hospital, Hinckley Hospital and St Peter's Health Centre) to have a standard photograph and a dermoscopic photograph of their skin lesion taken. These are encrypted and the dermoscopy image is analysed by DERM, Skin Analytics' artificial intelligence (AI) technology, and suggest a suspected diagnosis.

All benign images are reviewed by a SA Dermatologist, and patients are either discharged if confirmed as benign or referred for a review by UHL Dermatologists. All suspicious lesions, as well as all lesions marked as not assessed by the AI, are initially reviewed remotely by UHL Dermatologists, and if required seen face-to-face. Patients receive their results by letter in two to three weeks, or more quickly by phone if they need a face-to-face consultation.

Figure 3 Post-2WW Referral pathway for DERM, as implemented at UHL.



4.2.2. Key Dates

From the start of the pilot, four Community Hub sites have been rolled out, to allow patients to attend a site close to their home. The four Community Hub sites currently live are:

- Loughborough Hospital
- Melton Hospital
- Hinckley Hospital
- St Peter's Health Centre, Leicester City

Table 1 outlines the timeline of implementation for each hub.

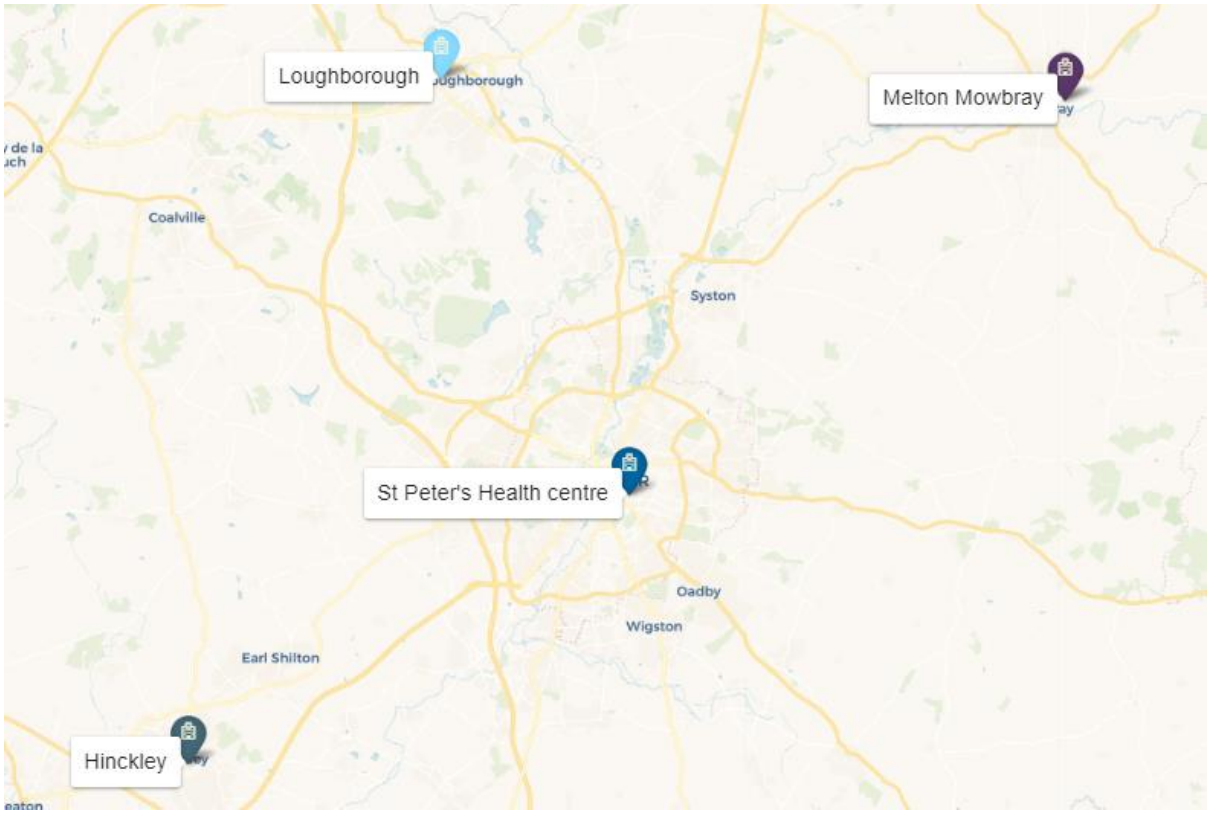
Table 1 Hub implementation timeline

Date	Description
28Th March 2022	First Community Hub site at Loughborough Hospital with Skin Analytics
21st June 2022	Melton Hospital live with Skin Analytics
14th July 2022	Hinckley Hospital live with Skin Analytics
18th July 2022	Leicester General Hospital live with Skin Analytics (now replaced by St Peter's Health Centre)

4.2.3. Clinic locations

Figure 4 gives a visual representation of where these clinics are located. Although all four hubs were reported as live by July 2022, the fourth hub (Leicester's City, later substituted by St Peter's Health Centre) saw less activity compared to the first three for the entire duration of the pilot. As of September 2023, all four hubs are now in use with a higher proportion of 2WW referrals being seen through the AI-teledermatology pathway – though this is not fully captured in the pilot data.

Figure 4 Map of UHL's Community Hubs



5. Aims, Objectives and Methodology for this Evaluation

5.1. Aims and objectives of this evaluation

This independent evaluation of Skin Analytics' AI-powered Teledermatology implementation within UHL aims to both quantitatively and qualitatively assess the impact of the pathway transformation on patients and care pathways as compared to standard care.

Key objectives of the evaluation were identified in the need to provide insights to inform:

- Cost-Effectiveness
- Impact on waiting lists and patients
- Quality and safety
- Patient and Staff Satisfaction

5.2. Methodology for this evaluation

The evaluation uses a mixed method methodology, combining patient and staff feedback surveys with data obtained from both UHL and Skin Analytics.

Quantitative analysis was completed using RStudio[31]. Data collected covered referrals and outpatient data from March 2019, up until March 2023. Skin Analytics data included all patients placed on the pathway until February 2023.

Pseudonymised patient level data was provided by UHL and Skin Analytics using the same pseudonymisation methodology to allow linkage of patients across referral, teledermatology and outpatient data. Linkage of the three dataset was used to estimate the volumes of 2WW referrals that had been seen through skin analytics, as well as the number of outpatient appointments following the AI-teledermatology pathway. Linkage of the three datasets also allowed an estimate of time on the 2WW pathway.

Skin-Analytics-held data was used to support the rest of the analysis, including insights on time for reviews, quality and safety. DERM diagnoses were grouped into malignant and benign categories to estimate time on pathway and provide an overview of histological diagnoses.

Surveys were also designed to allow our team to undertake a quantitative and qualitative analysis of staff and patients' perception of the AI-teledermatology pathway transformation at UHL, placing emphasis on their experience and perceptions of telehealth and AI based solutions in their care journey. These surveys were developed with clinicians, service providers and a patient librarian.

[31] RStudio Team (2021). RStudio: Integrated Development Environment for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/.

6. AI-Powered Teledermatology Impact Pathways

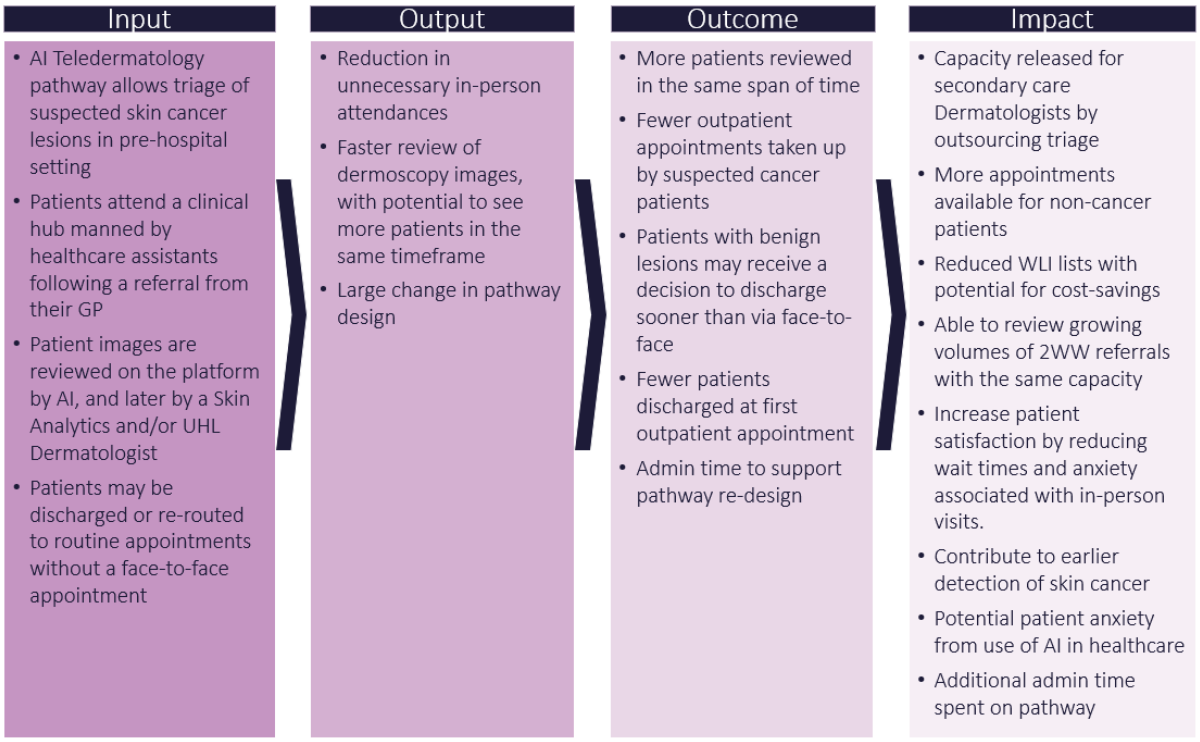
Section summary

Key insights from this section:

- The use of this AI-powered Teledermatology software has a number of costs and benefits.
- With input from clinical and operational staff at UHL as well as existing literature, a potential impact pathway has been developed which will be used to inform subsequent analysis.

Figure 5 sets out a potential impact pathway, which shows how the AI-Teledermatology pathway could impact staff, patients on a cancer pathway and the wider dermatology patient cohort. This impact pathway was constructed with input from consultants and operation staff as well as existing research. This impact pathway has been used to inform subsequent analysis.

Figure 5 Analysis of the potential impacts of the skin analytics-supported AI-Teledermatology pathway.



The "Input" stage of the logic model highlights the key activities where the AI-Teledermatology pathway allows the triage of suspected skin cancer lesions in a pre-hospital setting. Patients, referred by their GPs, attend a clinical hub staffed by healthcare assistants.

The "Output" stage sets out what happens as a consequence of the input, such as reducing in-person attendances or faster initial review of images.

The "Outcome" stage sets out what happens as a consequence of the output: fewer people needing to be reviewed in person, or more being reviewed in the same time period. Or patients with benign lesions may receive a discharge decision sooner than they would through a face-to-face encounter. Furthermore, the reduction of patients discharged at the first outpatient appointment may also contribute to improved efficiency.

Finally, the "Impact" stage summarises the impact associated with the outcome. For example, increased capacity leads to more dermatology appointments being available for 2WW patients. Or reduced waiting list initiatives (WLI), leading to potential cost-savings.

7. Pre- and Post-implementation Patient Pathways

Section summary

Key insights from this section:

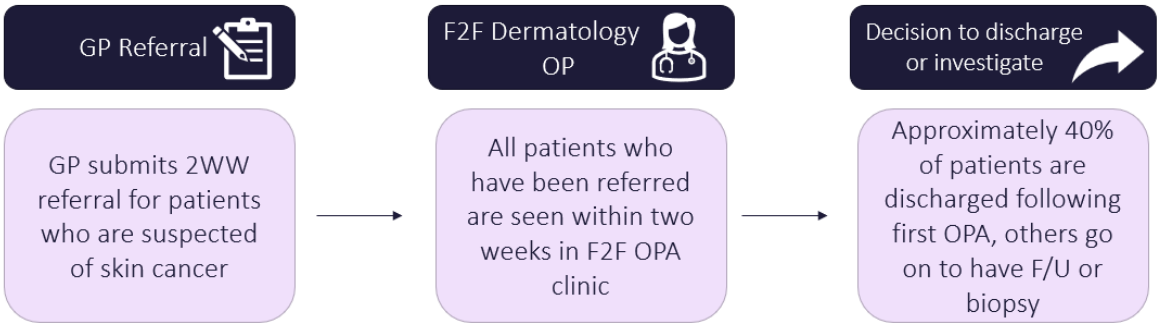
- The pre-intervention patient pathways for dermatology are simple. Post-intervention, during the pilot, the pathways are more complex with the image capture and AI-technology adding additional steps and outcomes resulting in additional decision points for patient pathways.
- 4,403 cases or 5,186 lesions were assessed on the post-intervention pathways by Skin Analytics during the pilot. These people had a range of different outcomes and pathway end points.
- Based on the available data, the demographics of the population assessed were similar to those assessed on the pre-intervention pathways.

7.1. Pre-intervention patient pathway

Before the introduction of Skin Analytics (SA), the patient pathway at UHL adhered to the conventional two-week wait (2WW) approach (Figure 6). Upon receiving a 2WW referral from a general practitioner (GP), all patients were targeted to receive a face-to-face OPA within this two-week timeframe.

During these appointments, patients were assessed by a consultant dermatologist, with the possibility of undergoing dermoscopy or minor treatments such as cryotherapy, based on the nature of their presentation. At this stage of the pre-intervention patient pathway, patients who were not suspected to have skin cancer were typically discharged. In contrast, patients with possible cancer indications would usually proceed to more invasive diagnostic procedures, such as biopsies, and/or be scheduled for subsequent follow-up appointments.

Figure 6 Summary of the traditional 2WW referral pathway, prior to the implementation of Skin Analytics AI-teledermatology.



7.2. Post-intervention patient pathway

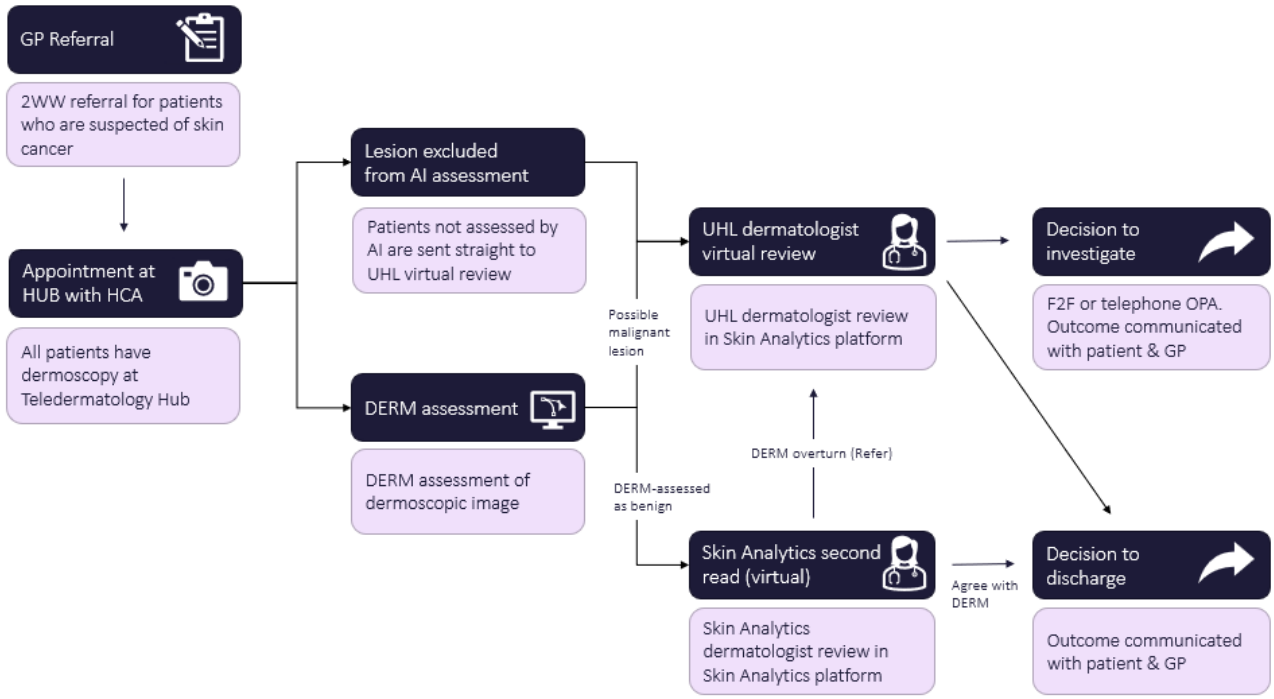
The adoption of the Skin Analytics platform introduced significant modifications to the patient pathway following a 2WW referral from a GP for suspected skin cancer (Figure 7). This system incorporates two additional steps, designed to enable the efficient triage and re-routing of patients before a face-to-face outpatient appointment, leveraging the capabilities of artificial intelligence and teledermatology for a clinical second opinion.

Patients deemed eligible for AI-assessed dermoscopy are directed to a Clinical Hub hosted at one of the four pilot sites. At these sites, a trained clinical photographer or healthcare professional captures an image of the patient's skin lesion. Each image is instantaneously reviewed by DERM, and patients are provided an AI diagnosis, as discussed in section 4.1.

Patients who receive a diagnosis of concern, or whose images could not be evaluated by the AI due to factors such as image quality, hair, tattooed skin, or excessively large lesions, are reviewed by a UHL consultant, first remotely and later face-to-face if required. On the other hand, during the pilot phase, lesions identified as benign by the AI are further reviewed by a Skin Analytics dermatologist[32]. These professionals either validate the decision to discharge the patient or refer them for additional assessment by a UHL dermatologist. All patients discharged through the platform are provided safety netting advice.

Where appropriate, patients on the AI Tele-Dermatology pathway then have a face-to-face review in a dermatology outpatient clinic. Following their outpatient appointment, patients are either directly discharged, continue on the cancer pathway or are scheduled for additional outpatient monitoring.

Figure 7 Summary of the post-intervention referral pathway, following the implementation of Skin Analytics AI-teledermatology.



[32] Skin Analytics employs consultant dermatologists on the GMC specialist register who work as NHS consultants elsewhere for this role.

7.3. Use of the pathway

Table 2 summarises the current use of the pathway up to the latest data time point of 8th February, 2023. This shows 4,403 patients and 5,186 lesions had been assessed to that date. The median age at assessment was 64 years old.

Table 2 Overview of patients assessed through the Skin Analytics platform as of 8th February 2023

Use of the pathway, as of February 2023	
Cases assessed	4,403
Lesions captured	5,186
Median age	64

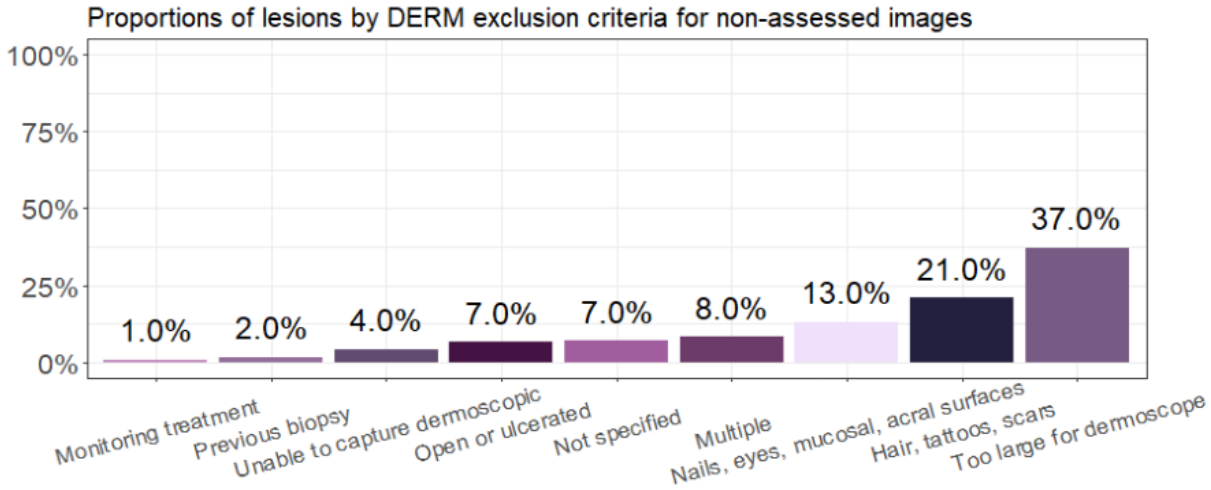
Out of the 5,186 lesions assessed by the AI, 44% were labelled as suspicious, versus 33.5% as benign (Table 3).

Table 3 Number and proportion of lesions assessed and not assessed by the AI, and distribution of benign and suspicious results.

Lesions assessed through the pathway	
Labelled as benign	1,740 (33.5%)
Labelled as suspicious	2,284 (44%)
Could not be assessed	1,162 (22.4%)

There were also 22.4% of lesions which could not be assessed by the AI due to several reasons, including hairs obscuring the lesion, images not meeting DERM quality assessment, lesions being too large to fit within the dermoscope, as illustrated below in Figure 8.

Figure 8 Reasons given by DERM for inability to assess dermoscopy images. *Note: "not specified" includes network issues or images not meeting quality standards.*



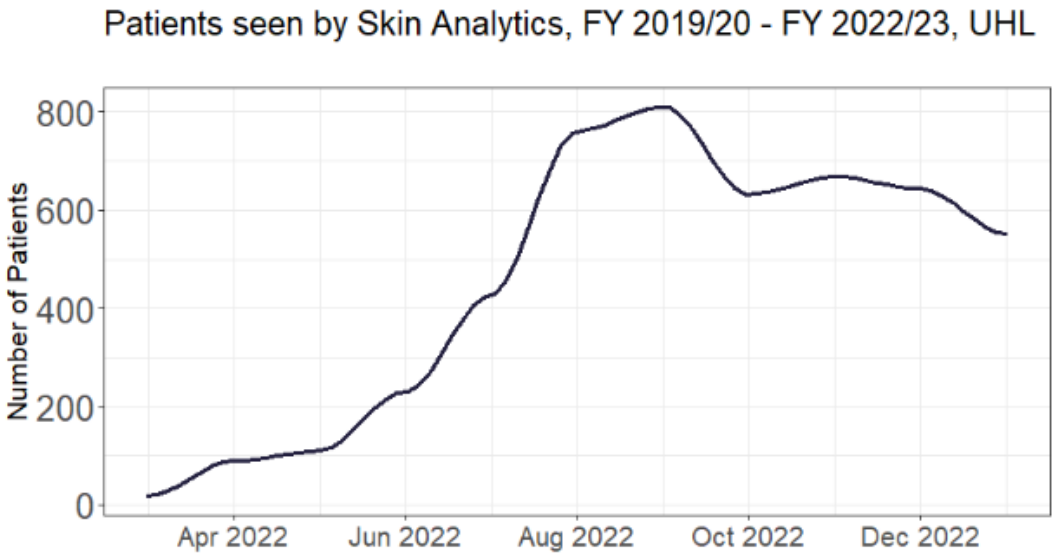
For patients seen through the AI-teledermatology pathway, the majority are either referred for an urgent outpatient F2F appointment (1,678, 38%) or discharged without an outpatient appointment (1,513, 34%). Others are either given a routine outpatient appointment (598, 13.6%), a urgent telephone consultation (433, 9.8%), an onward speciality referral (90, 0.2%), a direct to biopsy or excision referral (71, 0.2%) or a routine telephone appointment (20, 0.4%).

Table 4 Outcomes of patients who are seen through the AI-teledermatology pathway. OP: outpatient; F2F: face-to-face.

Patient outcomes on AI-teledermatology pathway							
Urgent OP F2F	**Routine OP F2F**	**Onward specialty**	**Direct to Biopsy or Excision**	**Urgent telephone**	**Routine telephone**	**Discharged without OP**	**Total**
1,678 (38%)	598 (13.6%)	90 (2%)	71 (1.6%)	433 (9.8%)	20 (0.4%)	1,513 (34%)	4,403

The number of 2WW referrals that have been assessed through the AI-teledermatology pathway has gradually increased since the pilot launch in March 2022 (Figure 9), with full capacity utilised from August 2022 onwards. By February 2023, approximately 75% of incoming 2WW referrals were being assessed through the platform, with an average of 32 patients per day being seen in the Community Hubs. At the latest data point, there was scope for further growth as this is slightly lower than seen at other DERM pilots, with evidence indicating penetration may reach up to 90% of the eligible population. More recent data collected by Skin Analytics suggests that UHL is already trending towards this figure as of September 2023, with up to 85% of patients being seen through the platform, the equivalent of over 900 patients a month.

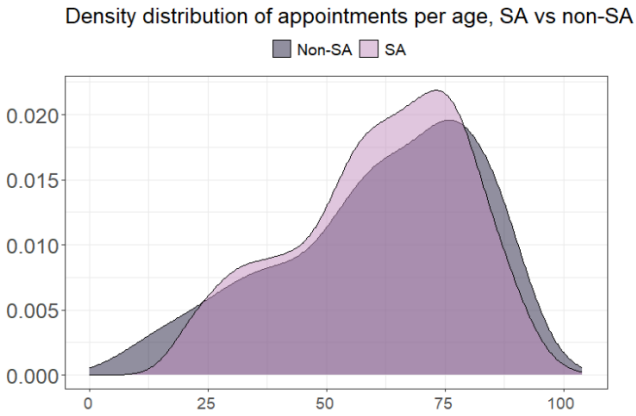
Figure 9 Number of patients assessed through the AI-teledermatology pathway, March 2022 - February 2023



7.4. Patient Demographics

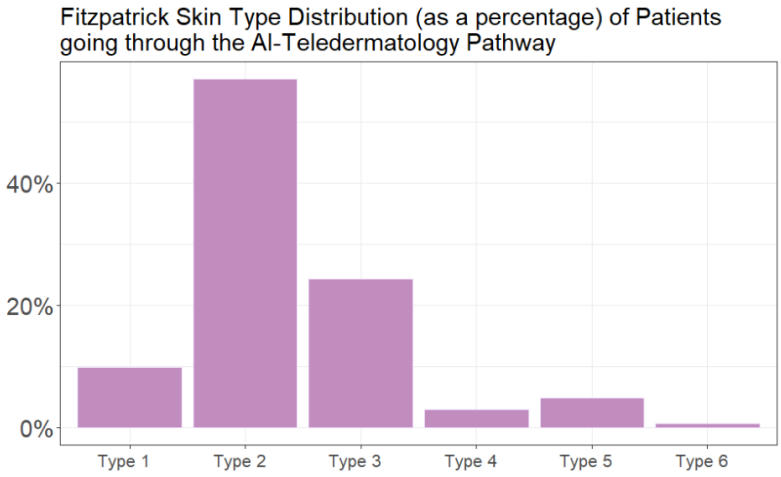
The age distribution of patients assessed on the Skin Analytics platform is largely similar to the population seen in face-to-face outpatients (OP) clinics (Figure 10), with the exclusion of under 18-year-olds and slightly fewer over 75-year-olds.

Figure 10 Density distribution of appointments per age group for patients assessed through the SA platform versus patients seen face-to-face at first OPA following a 2WW referral.



Patients belonging to a variety of Fitzpatrick skin type classification were assessed through the AI tool, with a prevalence of Types 2 and 3. Skin type was recorded for 99% of lesions captured, however this was an optional field filled in by Hub staff who are not formally trained in assessing skin type. No comparator was available in the non-AI-Teledermatology cohort, as skin type is not routinely collected as part of outpatient data. Further to this, the challenge of low incidence of skin cancer in higher Fitzpatrick skin types results in insufficient data to determine performance with statistical significance.

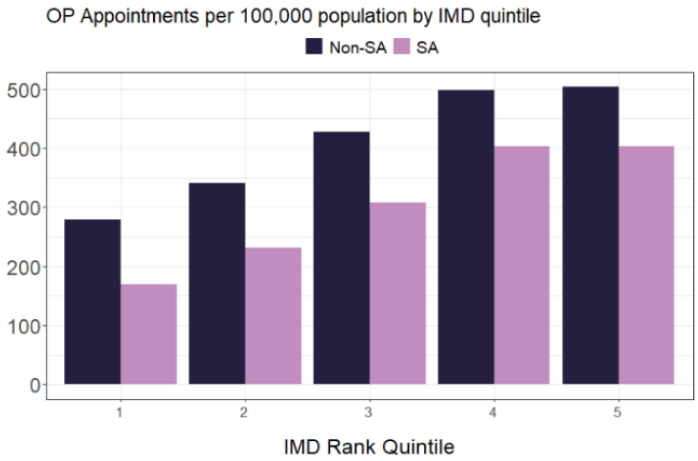
Figure 11 Proportion of patients on the AI-Teledermatology pathway by Fitzpatrick skin type



When assessing the distribution of Index of Multiple Deprivation (IMD)[33] rankings amongst patients who are seen in face-to-face OP appointments following a virtual dermoscopy review, versus directly face-to-face (traditional pathway), the picture is also largely similar (Figure 12). Appointments were standardised per 100,000 population in Figure 12, revealing, as expected, a larger number of face-to-face appointments across all non-AI-Teledermatology patients. However, the ratio of appointments between non-Skin Analytics and Skin Analytics patients across different IMD rankings remained largely constant.

[33] A measure of relative deprivation for small areas (Lower Super Output Areas (LSOAs). Quintile 1 is the most deprived and quintile 5 is the least deprived.

Figure 12 Appointments per 100,000 population by IMD rankings for patients seen face-to-face at first OPA following a 2WW referral, either post-SA or at first appointment.



8. Effects on Dermatology Service Capacity

Section summary

Key insights from this section:

- Trend analysis suggests there is some evidence that increased usage of the post-intervention pathway has led to a reduction in 2WW referrals at UHL more generally. This reduction in 2WW referrals appears to also be correlated with increased activity on other pathways suggesting that the intervention has helped increase capacity more generally.
- Based on available data, including assumptions from UHL, the new pathways may have led to a saving of 263 minutes per 100 patients, or 8.4 hours per week if scaled for UHL's referral volume, the equivalent of 0.2 of a WTE role.

8.1. Fewer outpatient appointments taken up by 2WW referrals

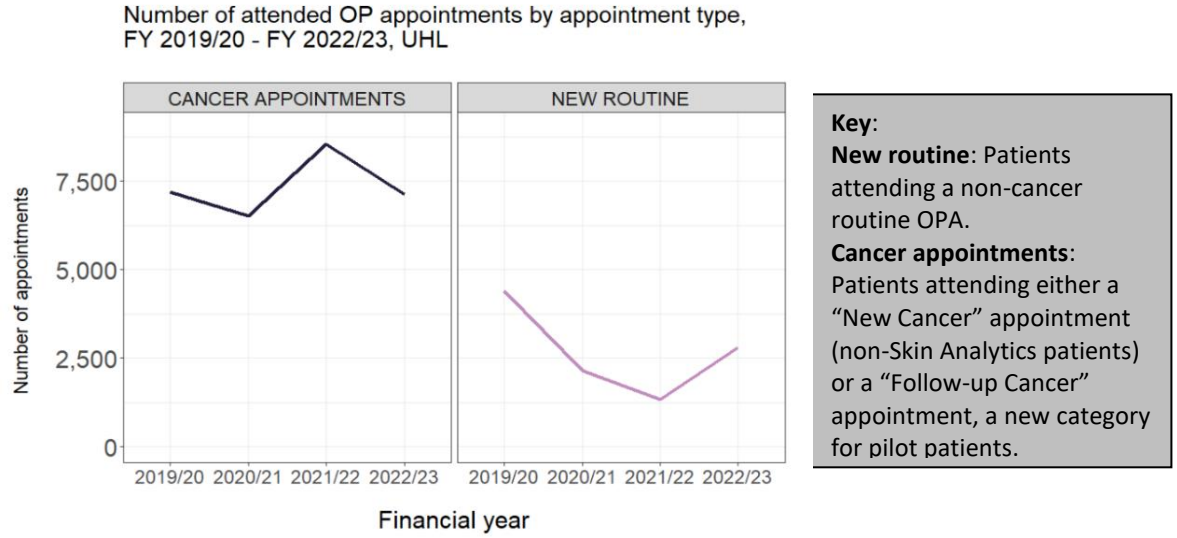
The first notable effect following the introduction of the AI-Teledermatology pilot on the Dermatology outpatient cohort was the overall decrease in OP appointments taken up by first 2WW cancer referral patients.

As shown in Figure 12, the overall number of OP appointments for new cancer referrals has decreased by approximately 1,450. The decline in appointments taken up by 2WW referrals has been matched by a rise in appointments taken up by non-cancer patients, such as "New Routine" patients.

This highlights the potential benefits of the pathway beyond 2WW referrals, as despite the rising volumes of 2WW, the new pathway has allowed for greater uptake of other dermatology appointments, rather than these diminishing under the pressures of urgent referrals.

The decrease in OP appointments for 2WW referral patients is related to the higher discharge rate across the AI-teledermatology pathway compared to the traditional face-to-face pathway, as well as the relatively high proportion of patients being discharged prior to a face-to-face appointment.

Figure 12 Trends in number of outpatient appointments attributed to cancer patients. Please refer to key for in-detail breakdown of groups. *Although some cancer patients may be captured under other groups at their first appointment, such as Biopsy or Excision, these form a significant minority of first face-to-face appointments and therefore were excluded from these counts. OPA: Outpatient Appointments*



Additionally, 46% of patients going through the AI-teledermatology pathway are discharged by the first face-to-face OP appointment, versus 40% of patients through the traditional pathway (Table 5). In addition, another 33% of patients proceed without needing a face-to-face appointment (e.g., have a telephone review).

Until February 2023 there were 1,487 avoided face-to-face appointments as a result of the pathway, which closely match the increase in other Dermatology outpatient appointments observed in the data.

Table 5 Summary of counts and proportions of patients who are discharged at different steps of their 2WW pathway, SA pilot vs traditional pathway.

Patients discharged at different steps of the pathway			
Skin Analytics Pilot Patients		***Traditional 2WW OPA Pathway***	
Following SA teledermatology review	811 (18%)	-	-
Following UHL teledermatology review	676 (15%)	-	-
Following first F2F OPA	570 (13%)	*Following first F2F OPA*	1,758 (40%)
Total	2,057	***Total***	1,758

8.2. Clinical reviews time savings

Another quantifiable benefit was the time taken per patient review between dermoscopy images and face to face patient review (Table 6). Each virtual dermoscopy review required on average **3.2 minutes** for a UHL Dermatologist to review on the SA platform (figure obtained from analysis of SA data), compared to **15 minutes** per face-to-face review (assumption provided by UHL consultant dermatologist). This suggests the Teledermatology pathway may allow up to 5-times as many patients to be reviewed by UHL within the same span of time.

Table 6 Time per patient review, pilot vs traditional pathway. Time per dermoscopy review obtained from SA platform data. Traditional 2WW review time as per clinical expert assumption.

Time per review	
Remote dermoscopy review	***Traditional 2WW OPA Pathway***
3.2 minutes (per lesion)	15 minutes (per patient)

Table 7 and Figure 13 show that for the traditional pathway, reviewing 4,403 patients would require 1,101 hours of clinic time. With the introduction of the AI-teledermatology pathway, the total time required was 908 hours, resulting in 193 hours saved compared to reviewing all patients face-to-face or through telephone review. This is the equivalent of a saving of 263 minutes per 100 patients. Scaled up to the expected volume of 2WW referrals for UHL of approximately 10,000 a year, this would result in a total time saving of 8.4 hours per week. This is the equivalent of 0.2 of a WTE[34].

The reduction in clinical time required to review 2WW referrals may be of considerable benefit to overly stretched secondary care providers. It allows for increased resilience in specialty clinics in the face of increasing volumes of 2WW as well as routine referrals.

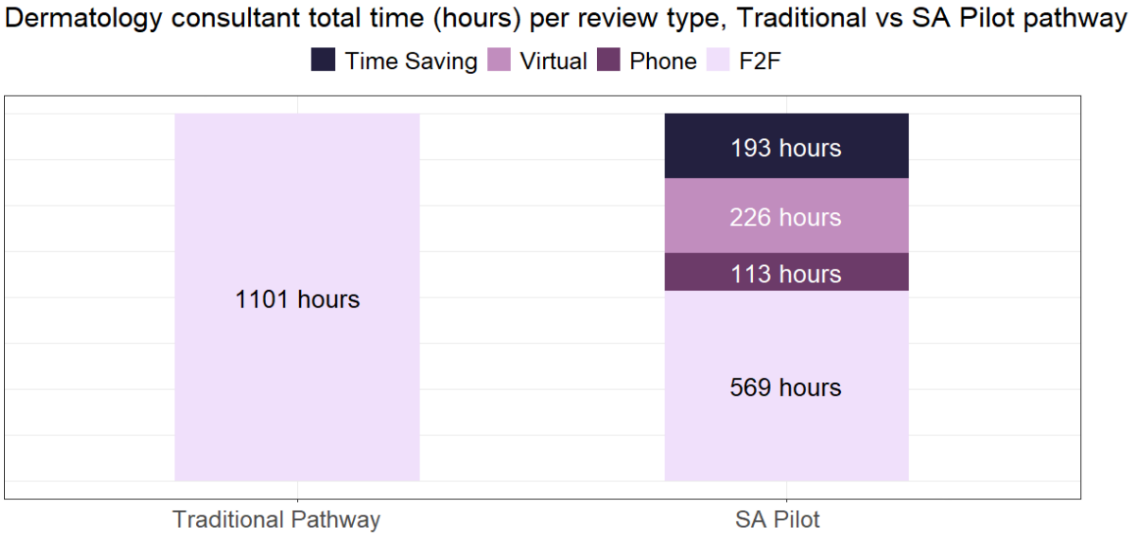
Given the known shortage of Dermatology consultants and recruitment issues, improving workflows and work efficiency may benefit both the wider Dermatology patient cohort as well as clinicians.

[34] Here we have used the NHS-BSA definition of a medical and dental WTE as 40 hours (or 10 planned activities).

Table 7 Summary of total time requirement per consultant review for cases at various stages in the AI-teledermatology pilot. *Note: some virtually reviewed patients will be followed-up on the phone or referred direct to excision or to another clinical specialty. We cannot account for UHL Consultant Dermatologists time following a remote review for these patients.*

Case cohort	*Count*	*UHL consultant average review time (per case)*	*Total time*
Lesions reviewed remotely by UHL	**4236**	3.2 minutes	226 hours
Cases reviewed face-to-face by UHL	**2276**	15 minutes	569 hours
Cases reviewed by telephone by UHL	**453**	15 minutes	113 hours
Total			**908 hours**

Figure 13 Overview of total time requirement for Dermatology consultants to review patients on the traditional vs pilot pathways, according to method of review (F2F or Virtual). *Time savings highlighted for the pilot pathway. Note that virtual reviews are counted by lesion, with each lesion review taking on average 3.2 minutes. Onwards time for reviews resulting in direct excision or biopsy and other specialty referrals are excluded from this count.*



Although the clinical triaging step prior to revieweing patients F2F after the AI may seem like a duplication of efforts, due to the AI's designed tendency to err towards caution, the remote triage reduces OPA volumes by 22% through both discharging and re-routing patients directly to treatment or other services, enabling both time and cost savings.

Table 8 Summary of outcomes following UHL or SA triaging by AI diagnostic cohort

Patient Cohorts	F2F or Phone appointment	Not seen in OPA
Possibly Malignant	1643	347
Possibly Bengin	417	1018
Not Assessed	669	309
Total	2729	1674

9. Patient Impact

Section summary

Key insights from this section:

- The time between referral and first face-to-face outpatient appointments was found to be significantly longer for the post-intervention pathways as a result of additional steps (image taking, review, possible additional referral), although in discussion it is clear that there is scope to reduce this additional time.
- Histology data was used to assess the sensitivity of the AI-powered solution. These data find that the AI-powered solution achieves high rates of sensitivity (i.e., correctly identifying potential cancers), which may be higher than those achieved by staff (although this was not analysed in this work).

9.1. Introduction

Ensuring patient safety is critical to the success of a programme such as this. Patient safety has been assessed by analysing the time patients spend on a pathway, from referral to first OP appointment, and by quantifying the agreement in diagnoses between AI and clinicians, including the rate of positive histology obtained from patients of concern. However, confirming clinical patient safety is beyond the scope of this health economic evaluation. Existing mechanisms within UHL to determine clinical safety should continue and be used alongside this evaluation.

9.2. Time on pathway and treatment breaches

The first metric assessed to assess patient safety is the time a patient spends on the pathway and any treatment breeches associated. The data indicates that patients on a AI-teledermatology pathway experience extended waiting times following a referral for 2WW suspected skin cancer referral.

For non-SA pilot patients, the mean time from referral to face-to-face OP appointment is 13 days and has remained unchanged compared to 2021/22. This time is considerably longer for AI-teledermatology pathway patients, for both potential melanoma and non-melanoma cancer, at 21 and 25 days respectively (Table 8).

Table 9 Median days between referral and first face-to-face (F2F) OP appointment (OPA) for non-SA and SA patients.

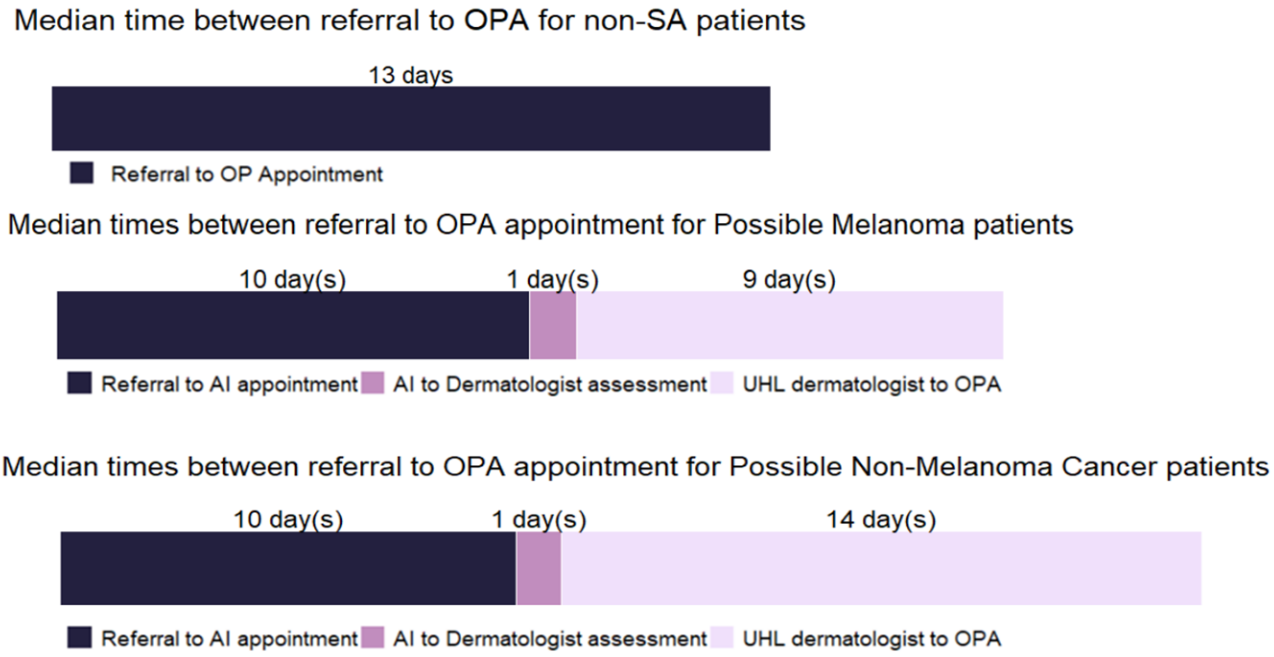
Median days to F2F OPA for potential melanoma SA patients	Median days to F2F OPA for potential non-melanoma cancer SA patients	Median days to F2F OPA for non-SA 2WW patients
21 days	25 days	13 days

The lengthening of the time in the SA patient pathway appears to be due to delays in two key steps (Figure 14):

- Time to be booked for a Community Hub appointment.
- Time to be booked for an OP appointment after triage of photographs.

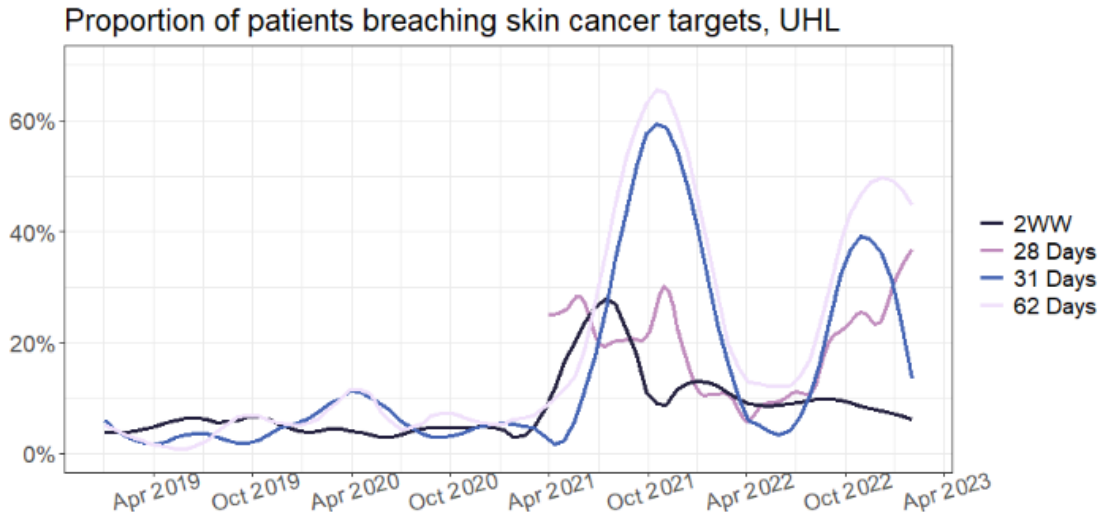
These results from a median waiting time from referral to attendance to a Clinical Hub appointment of 10 days on average, and a waiting time from a decision to review to the face-to-face appointment of 9-14 days.

Figure 14 Visual representation of time steps between referral and first face-to-face review for patients who have been flagged as potential melanoma or non-melanoma skin cancer following a UHL Dermatologist virtual review.



These delays appear to correlate with an increased percentage of breaches across 28-Days, 31-Days and 62-Days cancer targets (Figure 15), which have coincided with the implementation of the pilot. However, we can't conclude causation here as there are many potential factors influencing these targets. For example, the UHL team have reported known capacity issues with booking and admin teams and are being investigated. Similar delays have not been observed at other SA partner sites, such as University Hospitals Birmingham.

Figure 15 Proportion of patients breaching the cancer targets at UHL, between FY 2019/20 and FY 2022/23[35].



9.3. Histology and sensitivity

Additionally, the performance and safety of AI to discern benign from malignant lesions was assessed through histology-confirmed diagnoses of lesions who underwent biopsy. As of 8th February 2023, these amounted to 1,254.

Figure 16 illustrates the histology outcomes of lesions that were either marked as benign or suspicious by the AI or could not be assessed by the AI due to several reasons, including lesion being too large for the dermoscope, hairs, tattoos or skin marks obscuring the lesion or the image being out of focus.

Among the AI-assessed lesions, there were a total of 85 histology-confirmed melanomas and 390 non-melanomas (in this context: Squamous Cell Carcinoma (SCC), Basal Cell Carcinoma (BCC) and other rarer malignant cancers (Malignant "Other")).

All melanomas were flagged by the AI as suspicious, with 81/85 melanomas identified correctly, and 4 melanomas identified as benign by the AI but sent for further investigation by SA dermatologists. 382/390 non-melanoma cancers were correctly identified by the AI, and eight were not recognised (two BCCs, four SCC and two Malignant "Other") – all of which were assessed by the latest version of DERM. All were identified by SA dermatologists during the second read.

Among the biopsy cohort, the AI demonstrated 95% sensitivity for melanomas and 98% sensitivity for non-melanomas. The results are promising and so far, the AI may outperform clinicians on sensitivity, with clinician sensitivity reported at 94.5% (95% confidence interval (CI) 90.1% to 97.4%)[36]. Lesions that were not identified correctly were reviewed by SA and UHL dermatologists. In nearly all cases,

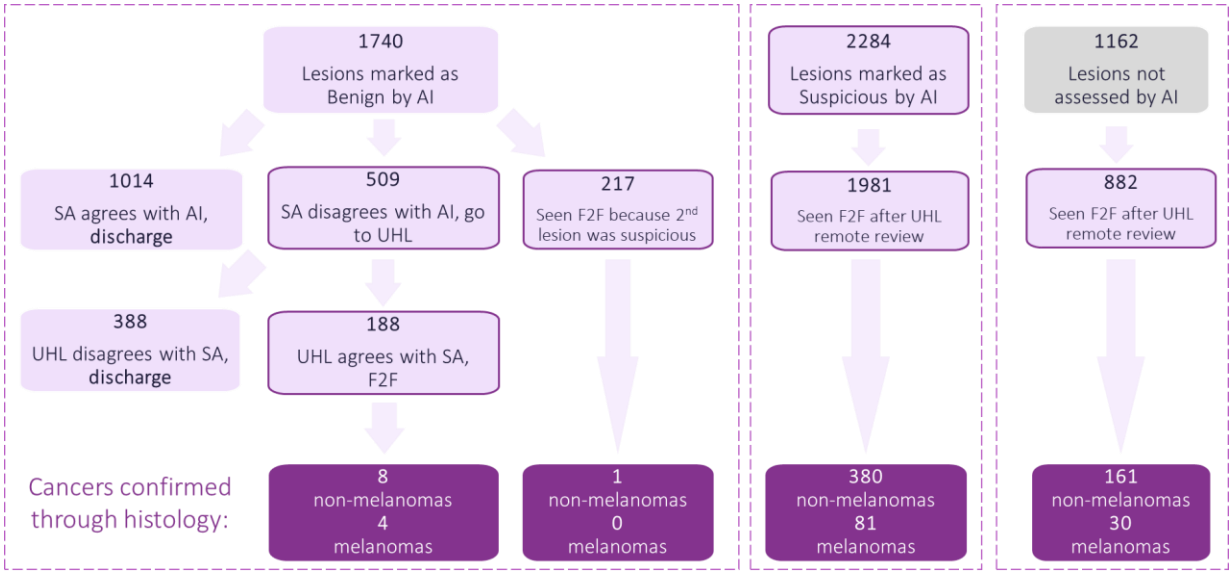
[35] Note, operational standards for cancer patients are as follows. 2WW: at least 93% of patients should be seen by a specialist within two weeks following a GP referral for suspected cancer. 28 Days: at least 75% of patients either receive a cancer diagnosis or have it ruled out within 4 weeks of an urgent GP referral. 31 Days: 96% of patients to start any type of treatment for a new primary cancer within one month from the decision to treat. 62 Days: at least 85% of patients to start their first treatment within two months of an urgent GP referral

[36] Chuchu N, Dinnes J, Takwoingi Y, Matin RN, Bayliss SE, Davenport C, Moreau JF, Bassett O, Godfrey K, O'Sullivan C, Walter FM, Motley R, Deeks JJ, Williams HC. Teledermatology for diagnosing skin cancer in adults. Cochrane Database of Systematic Reviews 2018, Issue 12. Art. No.: CD013193.

they agreed that diagnosis would have been challenging in a face-to-face context as well as teledermatology.

It is worth noting that, currently, a significant proportion of lesions flagged by the AI as benign are contested by SA dermatologists (29% of lesions) and are re-routed as requiring review by UHL. For 76% of these, UHL dermatologists refute the overturn and mark the lesion as benign. Despite the increased workload placed on UHL dermatologist, the second read of lesions has demonstrated to be valuable, as it supported the identification of 12 extra cancers, including four melanomas.

Figure 16 Map of lesions assessed through the AI-teledermatology pathway (n = 5,186) and their review journey through AI, SA and UHL dermatologists, and finally histology confirmed diagnoses in dark purple (n = 1,254).



10. Patient and Staff Experiences

Section summary

Key insights from this section:

- Patient experience with the AI-powered Teledermatology pathway has generally been positive and most would recommend the service to friends and family. However, this data is only obtained from patients at their first in-person contact with the service (the Community Hub), and therefore the analysis does not capture patients' opinions at later stages of the service.
- Staff experience collected through engagement and a survey (which only had six respondents, partly due to the size of the overall service) considered the second read requirement to be important for the overall service.

10.1. Introduction

As part of this evaluation, patient/carers and staff opinions of the tool have been collected through both surveys and interviews. The following section outlines the findings from these data collections. Full free-text responses are tabulated in the Appendix.

10.2. Patient Experiences

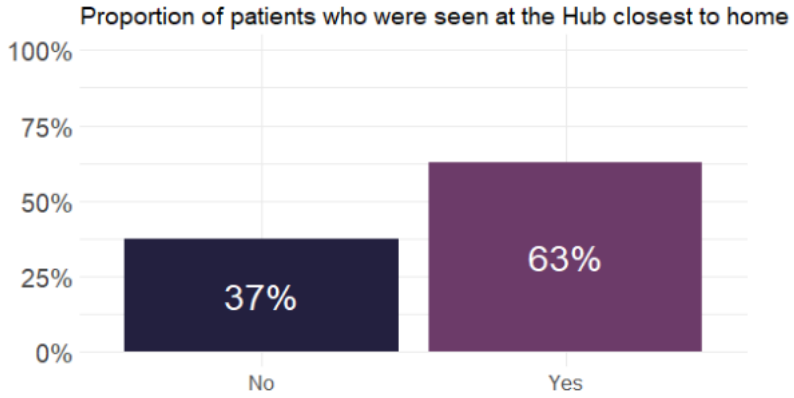
Patient experiences were gathered through paper questionnaires distributed to patients at the time of the Community Hub appointment in July and August 2023. In total, 115 paper surveys were returned for patients attending Hinckley (n = 53), Loughborough (n = 51) and Melton Mowbray (n = 11) hubs.

It is important to note that it was only possible to distribute surveys to patients at their first in-person contact with the service (the Community Hub), and therefore the following analysis will not capture patients' opinions at later stages of the service. This would include patients who have received a decision to be discharged or further appointment and may still be waiting to be seen face-to-face.

10.2.1. Patient travel to hub sites

Out of the patients surveyed, 72 (63%) reported attending the closest hub to home, as illustrated in Figure 17.

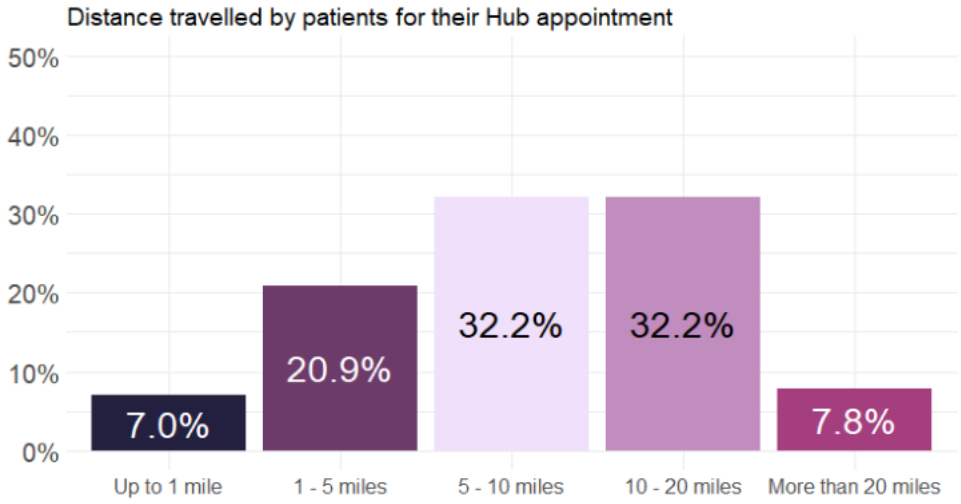
Figure 17 Proportion of patients seen at the Community Hub closest to home, n = 115



Although the majority of patients surveyed (60%) attended a hub within 10 miles of their home, a significant proportion of patients surveyed reported travelling 10 or more miles to attend a community hub appointment, including 8% of patients travelling more than 20 miles to attend their appointment (Figure 18).

It is worth noting that patients who may have travelled further than 10 miles have still reported that they visited the hub closest to home, and that some may have travelled the same distance to reach UHL prior to the pilot. Nevertheless, given the availability of four sites for hub appointments, this could be an area of improvement to reduce patient travel.

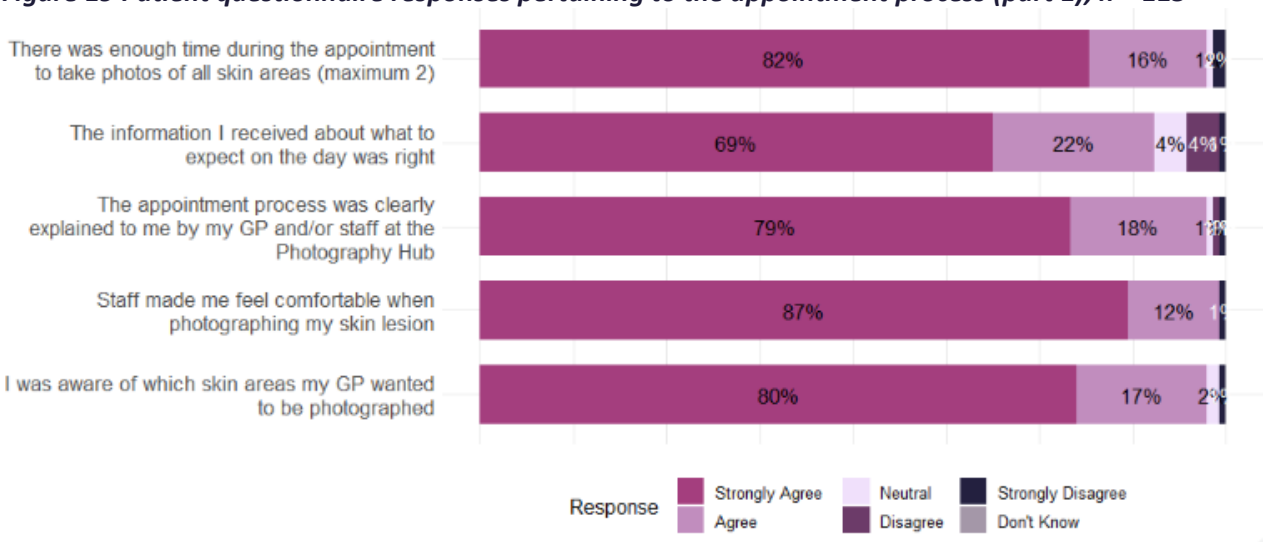
Figure 18 Proportion of patients by distance travelled to their Community Hub appointment, n = 115



10.2.2. Appointment Process

When asked about the appointment process, the majority of patients surveyed were satisfied with the quality of the service (Figure 19). Patients reported having received sufficient explanation prior and/or during the appointment and felt there was enough time for lesions to be photographed.

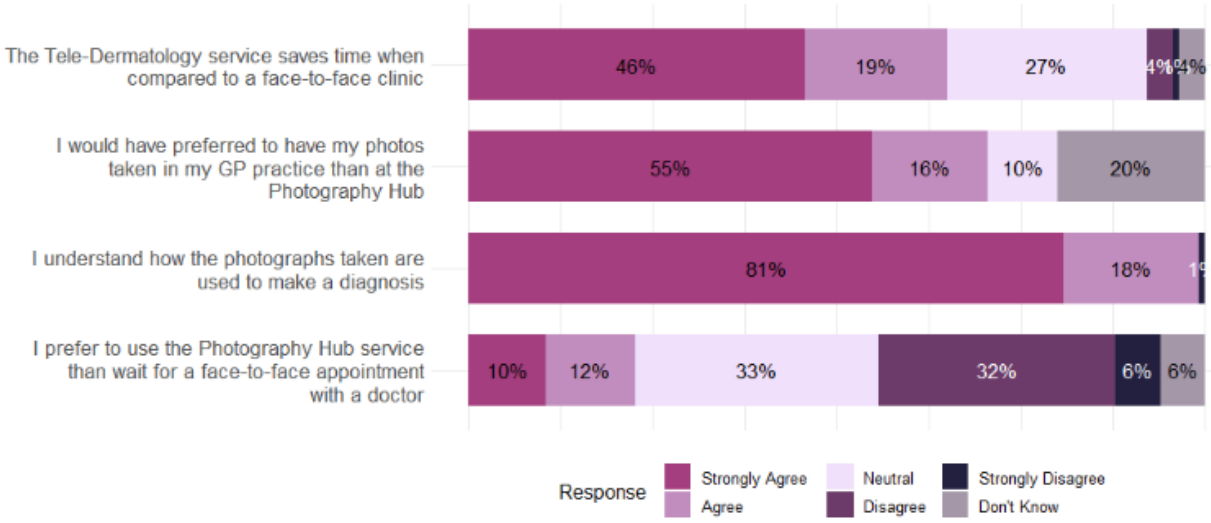
Figure 19 Patient questionnaire responses pertaining to the appointment process (part 1), n = 115



Of those surveyed, 99% of patients reported understanding how the photographs would be used to make a diagnosis, in keeping with previous statements on having received sufficient explanation for the service and the appointment process (Figure 21).

Although 65% of patients reported that the service saves time compared to a face-to-face clinic, 71% of them would have preferred for the photos to be taken at the GP practice rather than at the hub. Responders were also divided when asked whether they'd rather use the hub service than wait for a face-to-face appointment, with 38% of patients disagreeing with the statement, 22% in agreement and 39% neutral or unsure (Figure 20).

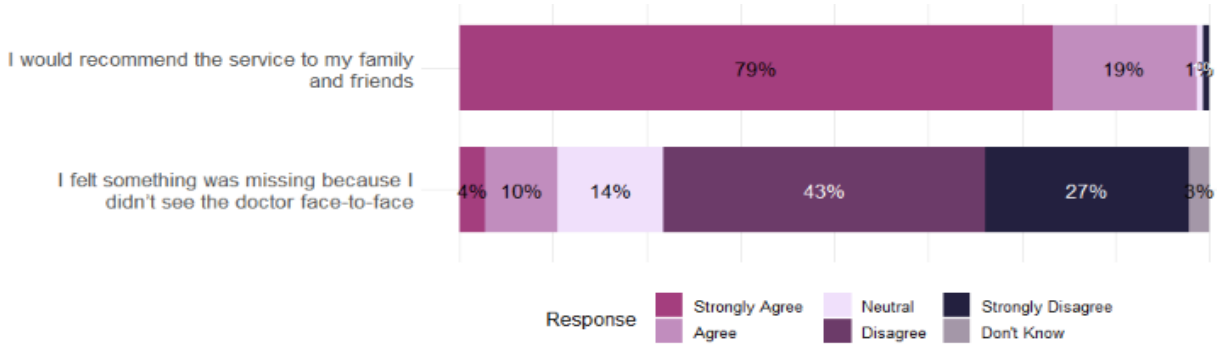
Figure 20 Patient questionnaire responses pertaining to the appointment process (part 2), n = 115



10.2.3. Satisfaction with the service

Overall, 98% of patients surveyed would recommend the service to family and friends, and the majority (70%) did not feel that something was missing due to not seeing a doctor face-to-face (Figure 21).

Figure 21 Patient questionnaire responses pertaining to satisfaction with the service, n = 115



In conclusion, the community hub service is providing a largely positively received service to patients. Further surveys would be required to assess more comprehensive patients' satisfaction that accounts for later steps in the pathway.

10.3. Staff Experiences

10.3.1. Staff Demographics

To date, 12 staff surveys have been returned, which include 6 Dermatology consultants and 6 Clinical Hub staff (which included two nurses and three health care assistants (HCAs)). This is a relatively small sample size.

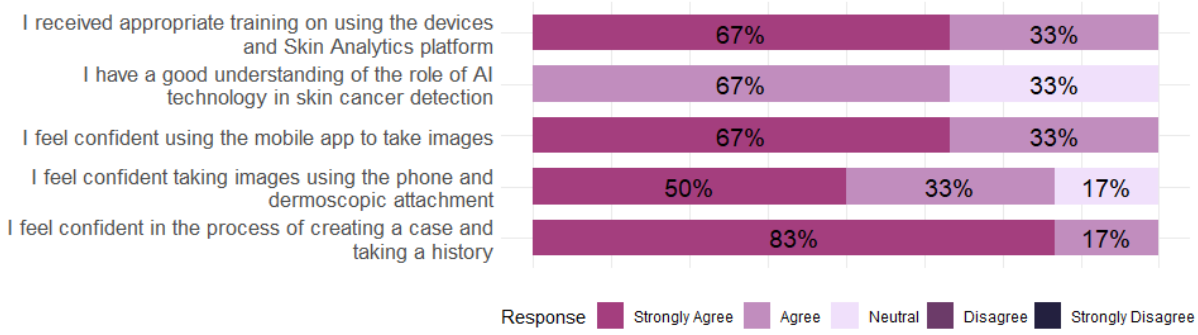
Staff were asked to select the most appropriate Likert scale response to a series of statements, which were tailored across two questionnaires to capture consultants and Hub staff differing experience.

10.3.2. Hub staff training

The hub staff who responded to the survey had an overall positive opinion of the process of reviewing patients at the Clinical Hub (Figure 22). They reported receiving adequate training on the devices and feeling confident in using the mobile app as well as creating a case and taking a history on the device.

Although 67% reported having a good understanding of the role of AI technology in skin cancer detection, about 33% did not agree or disagree with the statement. There may be an opportunity here to support Hub staff knowledge and understanding of AI to support patient care.

Figure 22 Community Hub staff questionnaire responses pertaining to training (n=6).

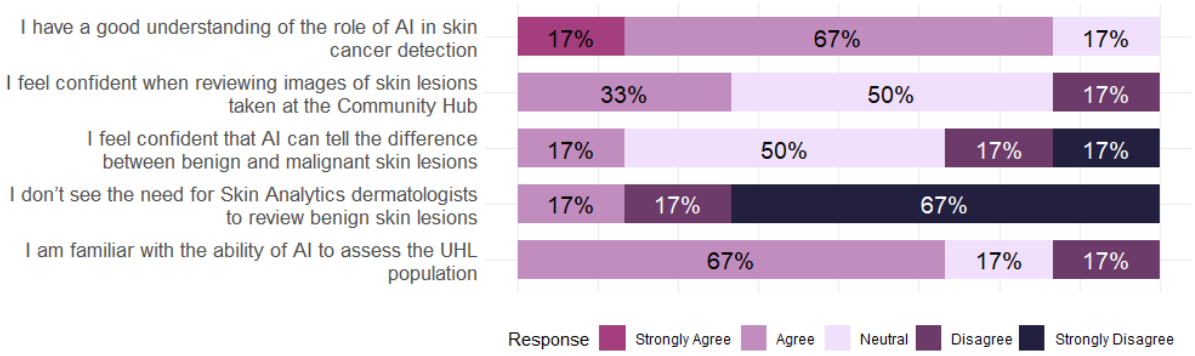


10.3.3. Consultants training and confidence in AI

The consultants who responded to the survey to date largely reported a good understanding of the role of AI in skin cancer detection and being familiar with the ability of AI to assess the UHL population (Figure 23). Responses were more mixed when reporting whether they felt confident reviewing dermoscopy images, with only a third agreeing with the statement, as well as whether the AI could reliably tell the difference between benign and malignant skin lesions, with 50% of respondents neither agreeing nor disagreeing with the statement and only 17% in favour.

The vast majority (84%) of respondents disagreed with a statement suggesting that there may be no need for a Skin Analytics dermatologist reviewing benign lesions.

Figure 23 Consultants questionnaire responses pertaining to training and AI (n=6).



10.3.4. Perceived benefits of the pathway

With regards to perceived benefits of the pathway, responses were mixed amongst Hub staff and consultants, with a significant proportion of respondents neither agreeing nor disagreeing with the statements provided (Figures 24 and 25).

Overall, Hub staff surveyed were more likely to agree that the new pathway allowed wider access to dermatology services and brought benefits to the trust and patients, whereas a third of consultants were more likely to disagree that the pathway allowed wider access to dermatology services.

Consultants were more likely to perceive that the pathway brings benefits to the trust rather than patients and that they were able to see more patients within the same span of time as the traditional pathway; however, the responses were mixed as to whether the AI-teledermatology pathway allowed the team to reduce the backlog, and as to whether it led to extra demand.

Figure 24 Community Hub staff questionnaire responses pertaining to perceived benefits (n=6).

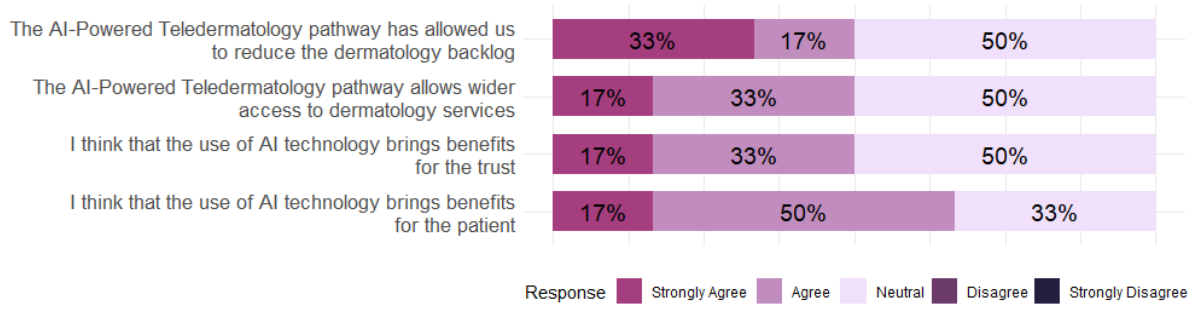
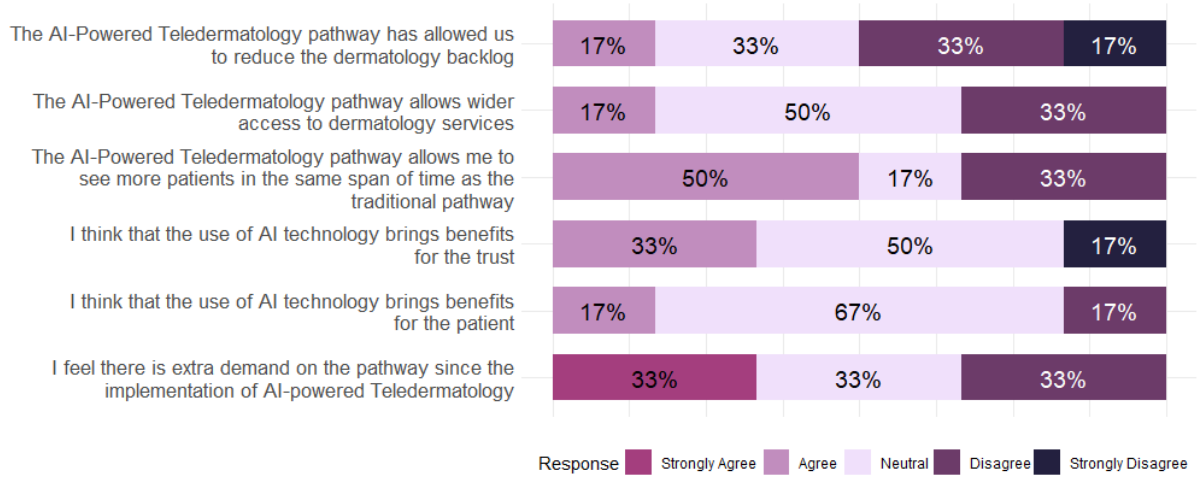


Figure 25 Consultants questionnaire responses pertaining to perceived benefits (n=6).



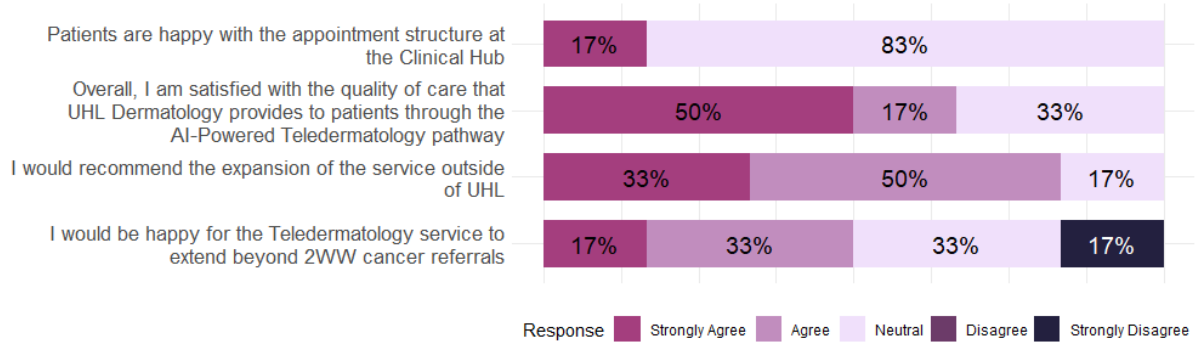
10.3.5. Quality and further expansion

With regards to the perceived quality of the pathway, and whether it may be recommended to other trusts or expanded beyond 2WW services, Hub staff and consultants had somewhat contrasting responses (Figure 26).

Hub staff surveyed were overall satisfied with the quality of care provided and 83% reported they would favour the expansion of the service outside UHL. However, responses were more mixed with regards to extending teledermatology beyond 2WW cancer referrals.

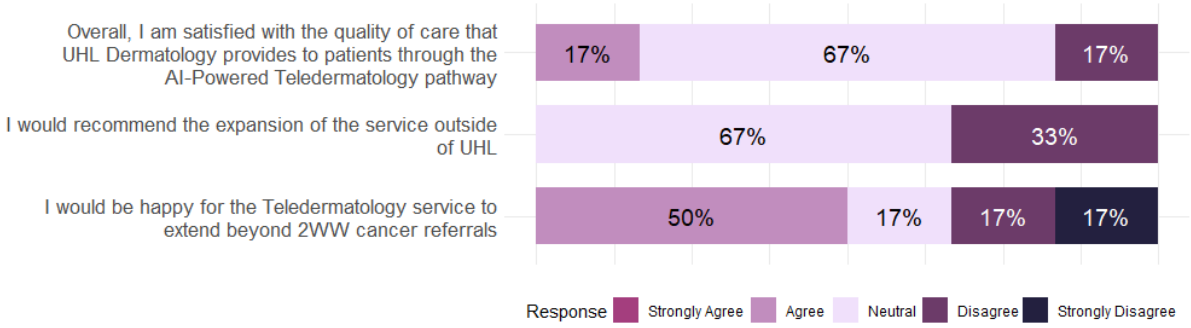
Additionally, 83% of hub staff surveyed were unable to say whether patients are happy with the appointment structure at the Clinical Hub.

Figure 26 Community Hub staff questionnaire responses pertaining to perceived quality and recommendations for expansion (n=6).



On the other hand, consultants were less likely to be satisfied with the quality of care provided and to recommend the expansion of the service outside of UHL, but 50% were in favour of extending the Teledermatology service beyond 2WW cancer referrals (Figure 27).

Figure 27 Consultants questionnaire responses pertaining to perceived quality and recommendations for expansion (n=6).



10.3.6. Other comments

The ambivalence across questionnaire responses was partly explored in the free-text feedback entered by both consultants and Hub staff.

Responses revolved particularly around two key themes:

- Concerns from both consultants and Hub staff about patient's spending more time on the pathway than previously, with long waits either side of their Community Hub appointment.
- Lack of confidence in different steps of the pathway, ranging from the quality of the images captured, the safety of AI and the skills of SA dermatologists.

Free text comments reported by staff members can be found in full in the Appendix.

11.Improved Value for Money

Section summary

Key insights from this section:

- The pilot achieved a benefit cost ratio of 1.05 from delivering £391,831 of benefit at a cost of £374,618. While this is lower than would ideally be achieved, it includes the cost of a second read and does not include the non-quantified benefits, including reduced WLI clinics, reduced biopsies and reduced long-term care costs.
- Indicative scenario analysis of potential alternatives for future models, which seek to mitigate the cost of the second read, lead to higher benefit cost ratios from 1.27 to 1.88. The highest, scenario 3, removes entirely the second read. Based on staff feedback, including in the survey, this scenario would require further local discussions prior to considering implementation.

11.1. Introduction

In order to estimate value for money and perform a cost-benefit analysis, we have relied upon data supplied by the Head of Financial Management at UHL, who provided us with the cost data for UHL's hub and programme setup, as well as information from the Operations & Finance Director of Skin Analytics.

Our forthcoming pilot analysis is based on a set of assumptions, shown in Table 10. Please note that assumptions for the cost of the SA service are different for the post-pilot period.

Table 10 Pilot Costing Assumptions

Assumptions	
Cost of F2F OP Dermatology Appointment at UHL	£216.46[37]
Cost of Telephone OP Dermatology Appointment	£151.52[38]
Consultant Dermatologist Hourly Unit Cost	£113[39]
Cost of SA service per case (pilot)	£40[40]

11.2. The Costs of the Pilot

The key costs incurred by the programme are staffing costs to run Community Hubs and Skin Analytics platform-related costs, which include the AI, the teledermatology platform and a remote review by Skin Analytics' dermatologists.

[37]UHL Patient Level Information and Costing System (PLICS) data provided by UHL Head of Financial Management

[38] As this figure could not be obtained through UHL's Head of Finance, we have estimated this using the National Schedule of NHS Costs 2021/22. Note that UHL-specific data was missing from this data set, so the national average ratio of cost for telephone OPA to cost of F2F OPA was applied to UHL's Cost of an OP Appointment.

[39] Unit Costs of Health and Social Care 2022, PSSRU

[40] Skin Analytics, Operations and Finance Director. All costs exclude VAT.

11.2.1. Staffing Costs

Based on the data provided by UHL, 7.64 WTE were required to provide workforce coverage to the four Clinical Hubs. We have not included costs pertaining to Consultant Dermatologists as all demand was absorbed by UHL's existing team. It is worth noting that teledermatology reviews were carried out in lieu of, rather than in addition to, existing activities by consultant.

A breakdown of staffing costs is outlined below.

Table 11 Staffing costs

Role	WTE	Total Cost
Admin/ HCA (Band 2)	2	£57,258
Admin for City Hub (Band 2)	0.82	£21,503
HCA (Band 2)	0.82	£21,504
Administration (UHL Cancer 2WW team) (Band 3)	1	£28,629
Administration/HCA (UHL Alliance Pillar) (Band 2)	3	£78,669
Total (annual)	7.64	£207,563
Total (10 months, duration of pilot period)	7.64	£172,969

For the purpose of this evaluation, we have provided a comprehensive total as per the costs provided by the Trust. All staffing costs were scaled to monthly costs and calculated for 10 months, to cover the period between end of March 2022 to the beginning of February 2023 and match the available patient level data used to evaluate benefits. It should be noted that, although staffing costs cover the whole pilot period, not all staff members were made available from the outset, and the service was not fully utilised for a portion of the pilot.

In summary, staffing costs for the pilot amounted to **£172,969** or **£39.28** per case.

11.2.2. Costs of Skin Analytics Service

The pilot cost of Skin Analytics amounted to £40 (excluding VAT), priced per case irrespective of the number of lesions captured (maximum 2). This cost included training, support, hardware, the teledermatology platform, DERM assessments and the second read. The total amounted to **£176,120**.

In addition to this, UHL consultants performed remote reviews of 4,236 lesions on the SA platform. According to the Consultant Dermatologist Hourly Unit Cost, and the average time per lesion review of 3.2 minutes, this cost amounted to **£25,529**.

When the above costs are combined with Hub staff costs **(£172,969)**, they amount to a total of **£374,618** the equivalent of **£85.08** per case for the duration of the pilot.

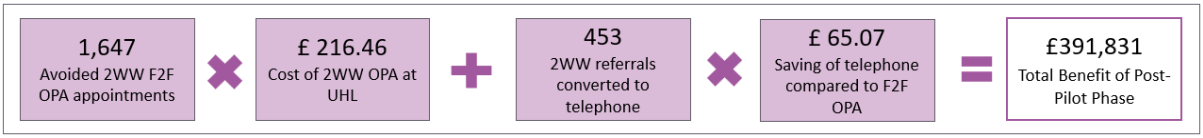
11.3. Quantified Benefits of the Pilot

The key quantifiable non-cash releasing benefit provided by the programme is the reduction in 2WW face-to-face OP appointments. Freeing up of OP resources means that they can be re-invested in other

activities such as tackling the OP Dermatology backlog and building resilience in the system in the face of rising volumes of 2WW referrals.

Following the introduction of the pilot, there were 1,647 fewer F2F 2WW appointments and 453 referrals were re-routed to a telephone consultation.

This equates to a total of **£391,831** or **£88.99** per case in non-cash releasing benefits.



However, it is important to note that it has not been possible for all benefits to be quantified to date. For example, savings from avoided biopsies. This is explored further in Section 12. If these were quantifiable at this stage, it is anticipated that the savings during the pilot would be substantially higher.

11.3.1. Constraints

Our analysis encountered a few constraints which has limited the number of benefits we are able to quantify. One such constraint was the difficulty in obtaining data on waiting-list-initiative (WLI) clinics, which attract a premium cost.

Additionally, we were unable to obtain data from UHL on the number of biopsies performed pre and during the pilot for dermatology patients referred under a 2WW protocol. Biopsy rates have been shown to decrease as a result of Skin Analytics at other pilot sites. Likewise, we were unable to obtain data on patient travel to clinical hubs and hospitals to compare the pre and post pilot periods.

Potential additional savings from saved WLI clinics and biopsies are explored in Section 12. When data becomes available, we recommend these benefits are quantified and included within future cost benefit analysis.

11.4. Pilot Benefit Cost Ratio (BCR)

Considering benefits that have been quantified to date, as well as three second read scenarios for the post-pilot period, we can quantify the BCR for the pilot and post-pilot phases (Table 11).

During the pilot phase, the programme proved to be cost-neutral – for every pound spent, the health system received £1.05 in benefits.

Table 12 Pilot Benefit Cost Ratio

Description	Pilot to data cut off (10 months)
Savings from avoided face-to-face OP appointments	£362,354
Savings from appointments re-routed to telephone	£29,477
Total Quantified Benefits	**£391,831**
Costs	**-£374,618**
Benefit Cost Ratio	**1.05**

11.5. Contracting Challenges

During the COVID pandemic, activity-based pricing was suspended and replaced with block contract agreements, but it is now being reintroduced in some trusts for certain services. Activity-based pricing is often used to align incentives and encourage productivity, but it can create financial problems between a provider and a commissioner, particularly when cost and finance are uncertain due to the introduction of a unique or novel service.

At initial pathway set-up, UHL was under a block contract agreement for its dermatology services. While the pilot was ongoing, the arrangement transitioned to a mix of activity-based pricing for initial visits and block funding for subsequent appointments. Our understanding is that this setup has resulted in financial concerns for UHL. In particular, UHL's activity following the initial hub appointment is financed through block funding, and not activity based. It is uncertain whether this block funding arrangement took into account the total cost of service delivery, and it appears that the use of AI-teledermatology has led UHL to miss out on potential income.

In the framework of this evaluation, it is crucial that cost considerations closely align with the cost of delivery, best mirrored in Patient-Level Information and Costing System (PLICS). However, it is important to remember that different contract setups can cause commercial concerns and difficulties. While understanding these is beyond the scope of this current work, it is essential to be aware of these potential risks when initiating a project like the one described in this evaluation.

11.6. Alternative scenarios for potential future consideration

There are a number of options for future consideration of AI-powered Teledermatology, which affect the benefit cost ratio. Largely these relate to mitigating the cost of the second read. To help provide an indicative understanding of the impact of these factors, a scenario analysis was undertaken to look at the following:

1. SA Costing Scenario 1: SA-dermatologists to perform benign lesions second reads
2. SA Costing Scenario 2: UHL-dermatologists to perform all lesions second reads
3. SA Costing Scenario 3: No second reads are formed for benign lesions

These three scenarios are considered further below. It is important to note that these scenarios are prospective and therefore indicative based on assumptions provided for this work.

11.6.1. Introduction

Since the implementation of the pilot, Skin Analytics' pricing has been updated and the second read provided by SA-employed dermatologists is accounted for separately and given as an option. The new pricing model is applied to a 10,000-catchment population and is broken down into costs for the AI, the teledermatology platform, as well as a discount if outcome data is shared with Skin Analytics, accounted for here. To provide an indicative and comparable assessment of costs, we have used Skin Analytics' market prices, however final prices are subject to Trust-based agreements. UHL's catchment population was estimated at 951,526 as per the NHS Acute (Hospital) Trust Catchment Population 2022 statistics, provided by the Department of Health and Social Care.

Table 13 Post-Pilot Population assumptions and Service Costs

Assumptions	
UHL Catchment Population	951,526[41]
2WW referrals going through AI-teledermatology pathway	9,437[42]
Cost per 10,000 population, SA service (post-pilot) – DERM assessment	£3,300[43]
Cost per 10,000 population, SA service (post-pilot) – platform	£900[43]
Discount if contributing outcome data (optional) per 10,000 population, SA	-£250[43]
Cost per remote lesion review by SA Dermatologist (post-pilot)	£17[43]

We outline three post-pilot costing scenarios, based on whether a second read is performed by a SA-dermatologist, by UHL-dermatologists or is entirely removed for benign lesions. The scenarios presented are to help understand the potential impacts of changing different elements of the pathway if the use of SA were to continue at UHL or at another Trust.

For the scenarios, we use the total volume of annual 2WW referrals to dermatology in UHL during FY 22/23[44] and apply the pilot proportions of patients reviewed remotely by SA and UHL, as well as face-to-face and through telephone appointments. As shown previously in the data, not all patients go through SA and therefore, we have scaled the total number of cases through SA down to 90% of the total to reflect figures observed across other Trusts employing the SA platform.

Although we are showing an increased activity volume through the hubs, we have assumed that staffing costs remain constant. This is because we anticipate the hubs have been underutilised during the earlier stages of the pilot and therefore, can support additional demand with the same staffing mix, as suggested by the recent increased volume of referrals seen through the hub without an increase in hub staff.

11.6.2. Post-Pilot Costs

SA Costing Scenario 1: SA-dermatologists to perform benign lesions second reads and UHL dermatologists continue to triage all cases not discharged by SA

The above scenario is the equivalent of retaining the pilot model, whereby a SA dermatologist will review all benign lesions and either discharge or forward to a UHL dermatologist, while all malignant lesions, as well as the ones that could not be assessed by the AI, are first reviewed by a UHL dermatologist remotely prior to a decision to review face-to-face.

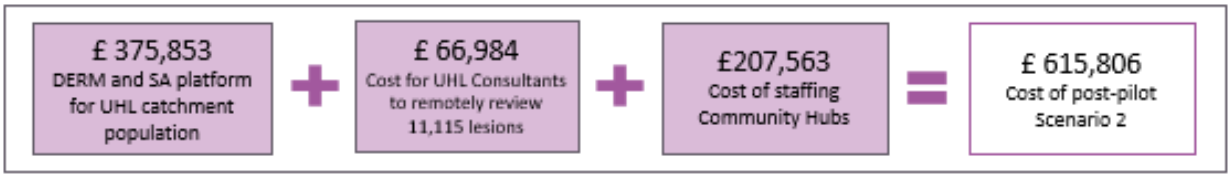
In this scenario, the total cost amounts to **£658,670** or **£70** per case.

[41] NHS Acute (Hospital) Trust Catchment Populations, 2022 Rebase Experimental Statistics, Office for Health Improvement & Disparities, Department of Health and Social Care
[42] Estimated from the number of 2WW referrals received in 2022/23 as provided by UHL (10,485) and the assumption that 90% of these will go through the pathway, as observed at other SA sites.
[43] Skin Analytics, Operations and Finance Director. All costs exclude VAT.
[44] As provided by UHL.

SA Costing Scenario 2: UHL-dermatologists to perform all lesions second reads

This scenario requires for all lesions to be reviewed by UHL, and an alternation to UHL Dermatology team job plan to include 49 hours of remote reviews per month, assuming the current proportion of lesions requiring review. Note that currently UHL reviews 82% of all lesions recorded through the platform, meaning that the increased workload is relative to this figure.

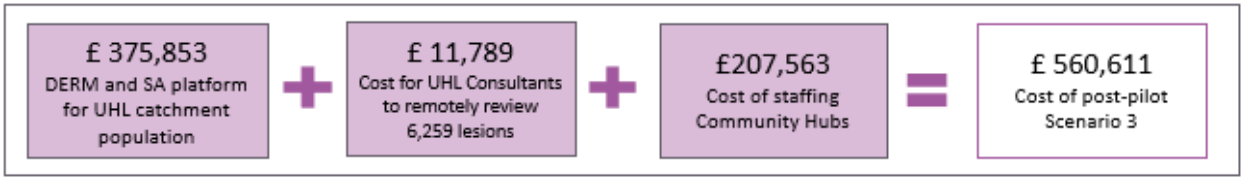
In this scenario, the total cost amounts to **£615,806** or **£65** per case.



SA Costing Scenario 3: No second reads are formed for benign lesions

If no second reads of benign lesions are performed, UHL dermatologists will only need to review lesions marked as malignant by DERM, as well as lesions that were not assessed by DERM. Local assessments will need to be completed to determine whether this option can be undertaken.

In this scenario, the total cost amounts to **£560,611** or **£59** per case.



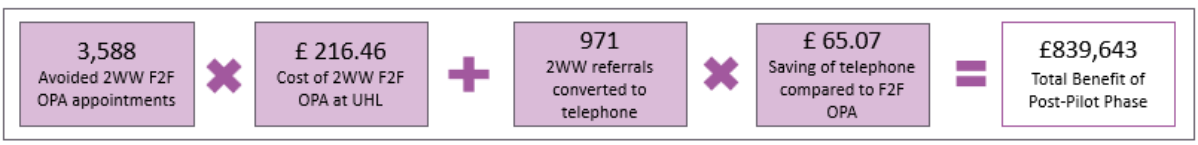
11.6.3. Post-Pilot Benefits

Non-cash releasing benefits predicted to be released by extension of the programme in future years are outlined across three scenarios, as per costs, depending on the preferred second read option.

Second Read Scenarios 1 and 2

Benefits released by scenarios 1 and 2 are equivalent to the pilot phase benefits. For the purpose of this evaluation, we have assumed that the same number of patients may be seen in a face-to-face 2WW or routine clinic, and discharged, independently from whether the second read was performed by a SA Dermatologist or a UHL Dermatologist.

The total benefits for these scenarios amount to **£839,643** or **£89** per case.

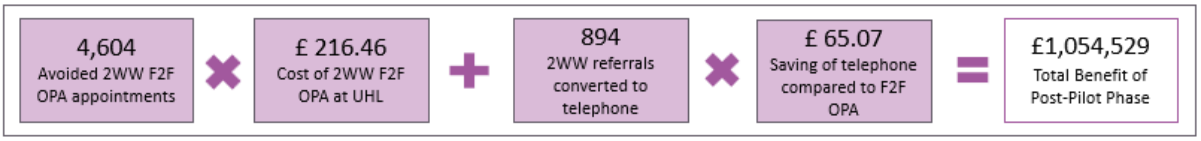


Second Read Scenario 3

In the absence of a second read of benign lesions, further benefits are seen by a higher volume of avoided 2WW face-to-face OP appointments, as no patients flagged as benign by the AI would be

overturned. Although the number of patients who are re-routed to routine appointments decreases, the quantified value of the benefit is higher, given the overall higher number of avoided appointments.

The total benefits for this scenario amount to **£1,054,529** or **£112** per case.



11.6.4. Post-Pilot Benefit-Cost Ratios

The estimates for the post-pilot period hinge on changes in the Skin Analytics cost model discussed at the start of this section. For scenarios 1 (SA performs second reads) and 2 (UHL performs second reads), the nature of the benefits remains the same as for the pilot period. However, for scenario 3, an increased number of 2WW appointments are avoided, leading to increased benefits. Together with a reduction in costs associated with fewer remote dermoscopy reviews, this leads to considerably higher savings.

These savings, however, will need to be balanced with the wider implications of removing clinical input over AI assessments of benign images. All costs and benefits have been scaled for catchment population, the expected number of 2WW referrals and to cover a 12-months period. Depending on which second read scenario is chosen, for each pound spent the health system receives £1.27, £1.36 or £1.88 in benefits (Table 12).

Table 14 Post-Pilot Benefit Cost Ratio

Description	2nd Read Scenario 1	2nd Read Scenario 2	2nd Read Scenario 3
Savings from avoided face-to-face 2WW OP appointments	£776,596	£776,596	£996,493
Savings from appointments re-routed to telephone	£63,046	£63,046	£58,036
Total Quantified Benefits	**£839,643**	**£839,643**	**£1,054,529**
Costs	**- £658,670**	**-£615,806**	**-£560,611**
Benefits Cost Ratio	**1.27**	**1.36**	**1.88**

12.Additional Non-Quantifiable Benefits and Costs

Section summary

Key insights from this section:

- There are a number of different benefits, which have not been captured in the above analysis. These include reduction in biopsies, reduction in longer-term care costs, and a reduction in WLI clinics.
- Additionally, there are some additional costs that will need to be considered, such as administrative costs of significant pathway re-design.

12.1. Introduction

Beyond the quantifiable benefits elucidated earlier, there are several non-quantifiable benefits and costs that result from the implementation of this program.

Some of these are non-quantifiable due to lack of access to the required data (detailed in Section 13.2.1) and some due to the nature of the benefit or cost. The benefits and costs that have not been quantified as part of this report due to data availability, should be quantified when data becomes available. This includes saved biopsies and reductions in required WLI clinics.

12.2. Non-Quantifiable Benefits

12.2.1. Potential to reduce biopsies

Although we were unable to ascertain the difference in the biopsy rates between Skin Analytics and non-Skin Analytics patients due to lack of data, it is conceivable that a decrease in face-to-face 2WW appointments may lead to a reduction in the number of patients undergoing biopsies.

This not only spares patients an uncomfortable procedure and additional uncertainty about their condition but also alleviates the demand on the healthcare system. Given the AI's correlation with histological diagnosis, there is scope for even further reduction in biopsies as trust in the tool increases and technology develops.

For example, if we assume a 10% reduction in biopsies as observed at other SA sites and take the 1,254 biopsies performed on the SA UHL cohort until February 2023, we may expect 139 avoided biopsies. Using a cost of £251 per biopsy[45], this could result in a saving £34,889 over the pilot period. Scaled to the yearly 2WW volumes, this rises to £74.547 (297 avoided biopsies for 9,437 referrals). However, more data is required to confirm these assumptions.

12.2.2. Potential to reduce longer-term care costs

Another key potential benefit of the use of SA is reducing the number of missed melanoma or non-melanoma cancers. Under the current model of care, the patient's lesion is checked by AI and a consultant dermatologist. During the pilot, there was no evidence that a patient with either melanoma or non-melanoma cancer re-presented within 6 months for the same lesion.

Melanoma has 100% 5-year survival rates when diagnosed at stage 1 disease but drops to 30% by stage 4. Diagnosing cancer through the 2WW referral route is associated with earlier stage at diagnosis, which not only impacts survival but also costs of care. With a difference between treatment costs for Stage 1 vs Stage 4 melanoma of up to £4,000[46], each case detected through the 2WW pathway could enable significant savings to the health system.

12.2.3. Savings of WLI clinics

There is also the possibility of cash-releasing benefits from avoiding the need for WLI clinics. These are clinics run alongside 2WW clinics to help reduce the waiting list, which are put on at a premium

[45] National average for biopsies recorded under Dermatology, National schedule of NHS costs (Year 2021/22)
[46] The likely impact of earlier diagnosis of cancer on costs and benefits to the NHS. Frontier Economics on behalf of Department of Health the National Awareness and Early Diagnosis Initiative (NAEDI). January 2011.

cost. Therefore, the reduced need for WLI clinic through reducing demand on the service through the use of SA could deliver significant cash-related benefits.

12.2.4. Supporting the dermatology outpatient list and equitable access to care

A notable rise in activity for the general dermatology outpatient waiting list was observed, as previously discussed in section 9.2. This upsurge suggests that the pilot helps in shifting capacity from catering disproportionately to 2WW patients, broadening its reach to a larger patient demographic.

The increase in new routine dermatology appointments particularly signifies that the program can be instrumental in tackling the general dermatology backlog, which under ordinary circumstances, risks growing as the system must prioritise the most urgent cases. Hence, this ensures a more equitable access to care for patients who may not require a 2WW referral but could still benefit from a specialist dermatology opinion. The program thereby helps in the redistribution of finite resources in a more balanced manner.

12.2.5. Supporting the workforce

Additionally, this initiative has the potential to provide significant benefits to staff. Remote skin analytics reviews take approximately one-fifth of the time compared to regular face-to-face appointments. This efficient use of time, even with an increased volume of remote reviews, allows consultants to dedicate more time to other patients and perform other crucial tasks, both clinical and administrative, and support observed workforce shortages.

The AI serves as a useful decision-aid tool, proven highly effective in cancer detection and providing support in uncertain clinical situations. As AI becomes an increasingly integral part of modern healthcare, familiarising and understanding this technology equips the staff with the capability to use it safely, understand its limitations and risks, and keep abreast with the latest technological advancements, thereby enabling better patient care.

12.3. Non-Quantifiable Costs

12.3.1. Potential increase in administrative costs

The change from the traditional pathway to the novel AI-powered Teledermatology pathway is significant. There are changes to different stages of the referral pathway, including from the GP and within secondary care. Changes to referral pathways of this size do sometimes cause additional admin burden for the health system. This additional burden may come in the form of increased time spent replying to queries from staff and patients involved in the pathway as well as developing new patient information sheets.

12.3.2. Potential costs to delayed treatment

As described above, the hope is that the use of the AI-powered Teledermatology software could reduce delays to treatment through supporting the outpatient dermatology waiting lists and supporting the existing workforce. However, given the reported challenges with implementation at UHL, currently patients on the AI-powered Teledermatology pathway wait longer to be seen face-to-face compared to patients on the traditional pathway.

If this continues, there is the risk that this could result in additional costs to the pathways. For example, patients may receive treatment later and therefore require more contacts with the health system.

13. Midlands-Wide Scaling

Section summary

Key insights from this section:

- Based on the above analysis, removal of the second read could lead to Midlands wide benefits in the region of £5.5 million.

The benefits we have quantified can be scaled to estimate the potential savings if the AI-Teledermatology pilot is expanded to other sites across the East Midlands.

To calculate this, we apply the net benefit per patient to the number of 2WW referrals for possible skin cancer that have been recorded across the Midlands region for the financial year 2022/23, using data provided by the NHS Digital[47]- amounting to 121,809. These have been scaled to 90% (109,628), maintaining the ratio of 2WW referrals undergoing the AI-teledermatology pathway, as observed at UHL.

In view of changes to the Skin Analytics costing model that are likely to apply to all trusts who adopt the service from now onwards – although specific contracts are likely to be developed on a one-to-one basis –, we have accounted for these new costs, rather than the UHL pilot costs, to apply Midland-wide scaling.

In keeping with our UHL-specific analysis discussed in the previous section, we provide three scenarios based on who performs the second read of the lesion.

Based on these assumptions, the yearly net benefits across the Midlands amount to either **£2,102,436**, **£2,600,411** or **£5,738,072** depending on the chosen second read scenario (Table 13).

The significant difference between the first two scenarios and the third is due to the contribution of both considerably fewer 2WW outpatient appointments, as well as a decrease in consultant's time for remote reviews.

It is worth noting that the costs for outpatient appointments are likely to vary across sites; to ensure maximal accuracy of these estimates, individual Trusts' costing data should be taken into account.

We have maintained the benefits and costs per head calculated from the post-pilot period. As previously mentioned, these may vary with a higher volume of patients, as some fixed costs are involved.

Table 15 Net Benefits for the Midlands Region

Description	2nd Read Scenario 1	2nd Read Scenario 2	2nd Read Scenario 3
Benefits (per referral)	**£88.98**	**£88.98**	**£111.75**
Costs (per referral)	**£69.80**	**£65.26**	**£59.41**
Net Benefits (per referral)	**£19.18**	**£23.72**	**£52.34**
Net Annual Benefits	£2,102,436	£2,600,411	£5,738,072

[47] NHS e-Referral Service (e-RS) open data dashboard, NHS Digital (accessed July 2023)

14. Findings and Recommendations

14.1. Key Findings and Considerations

Our analysis has highlighted several insights regarding the implementation of the pathway, its effects on dermatology service capacity, time efficiencies achieved through patient reviews, patient safety considerations, and reflections on staff experiences.

Regarding the use of the pathway, it has seen a gradual increase in the number of 2WW referrals assessed since its launch, with volumes reportedly increasing throughout the post-pilot period. There has been a decrease in face-to-face outpatient appointments taken up by 2WW cancer referral patients.

Furthermore, the time efficiency of virtual dermoscopy reviews conducted via the pathway outperforms traditional face-to-face reviews. On average, a virtual review required 3.2 minutes compared to the 15 minutes necessitated by a face-to-face review. Although the impact of this is reduced by the increased number of remote reviews compared to a single OP appointment, it still resulted in a total time saving of 193 hours of consultant time during the 10 months of the pilot, equivalent to 8.4 hours per week for 10,000 referrals per year. There is a potential for this time saving to increase, depending on how reviews are performed with a possibility for the pathway to support greater volumes of patient reviews within the same timeframe, thus alleviating the wider backlog and support national cancer targets, though we do not yet have evidence of that.

Patient safety has been assessed by analysing the time patients spend on the pathway and the agreement in diagnoses between AI and histology. The data indicates that patients on the AI-teledermatology pathway experience extended waiting times following a 2WW referral. Delays in booking Community Hub and outpatient appointments have been identified as the key factors to these prolonged waits, rather than the technology. With regards to histology, the AI showed a sensitivity of 95% for melanomas and 98% for non-melanomas, comparable to documented clinical performance.

The report also presents findings related to staff and patient experiences. Generally, staff members reported a positive experience with the pathway, asserting satisfactory training and confidence in utilising the technology. Nevertheless, reservations were voiced regarding patient waiting times and the trustworthiness of various stages within the pathway. Patients were surveyed when attending for the first Community Hub. Overall, they expressed satisfaction with the service at that point in the pathway, with particular emphasis on the quality of the appointment, even though 37% did not attend the hub closest to home.

Cost-benefit analysis of this pilot to date showed cost effectiveness during the pilot, with greater benefits if the programme is continued further. The analysis found that for each pound spent on the AI-Powered Teledermatology Pathway for 2WW Skin Cancer, the health system received £1.05 in benefits. Following the new costing model for the Skin Analytics platform, and with full utilisation of the service, benefits range from £1.27 to £1.88 per pound spent depending on who performs the second read.

Amongst the key benefits, however, there are non-financial advantages, including supporting the dermatology backlog and coping with staffing constraints, which are key to account for when considering the wider scope of the pilot.

14.2. Recommendations

Considering our analysis and the findings of this report, there are a number of recommendations that we put forward to optimise the benefits of the pathway.

14.2.1. Streamline pathway efficiency and minimise waiting times

Service providers should prioritise addressing the delays associated with booking Community Hub and outpatient appointments to reduce waiting times for patients utilising the Ai-teledermatology pathway. The current delays observed in the pathway have the potential to pose a potential risk for patients who are later confirmed to have cancer, as their overall treatment may be delayed, as well as for patients who await to be discharged from the service who are likely to worry until a decision is made.

The delay that is perhaps easier to address is the first lag of time between a referral and attendance to a Community Hub. The local team are aware of challenges related to the observed delays and are in the process to address them.

Examples of potential solutions discussed include moving away from a post-referral model. In a pre-referral screening model, patients could have their required photos taken either by their GP or within their GP practice as part of their initial consultation. This means that the patient would remove the initial 10 day wait to have photos taken at the hub and instead, if required, be sent straight to virtual review by a dermatologist.

This model may also find further approval within the patient population, who expressed a preference to be assessed at their practice rather than at the community hub. It might also improve travel times to the hubs.

Although this has the potential to deliver additional benefits, there are challenges with its implementation. These challenges are part of the reason for the decision for a post-referral model originally. The challenges include, engaging and gaining buy-in from large portions of the health system and coordinating significant shifts in referral patterns. For example, the pre-referral model places more expectations on GPs who are currently under significant pressure.

Skin Analytics are running ongoing trials for similar pathway models, and local provides are encouraged to share learnings and consider possible options to implement the pathway. Using the available data, internal discussions within UHL must weigh the challenges with the benefits of shifting the delivery model.

14.2.2. Trusts will need to independently assess the best care model

As described in the report, the cost model for Skin Analytics is changing. The potential implications of these changes have been detailed in the scenario modelling, which demonstrates differing impacts of potential care models.

Overall, the new cost model could lead to the cost of a review by a SA dermatologist increasing significantly, potentially leading to a reduced or negative benefit cost ratio. These implications will need to be considered locally. For example, discussions around whether the increased pressures on UHL staff to complete the second read would lead to a sufficient increase in the discharge rate to make it worth it form both a capacity and cost-effectiveness point of view.

UHL have identified as a potential solution whether different care models could be applied to patients depending on whether they were referred on the local melanoma or SCC pathway, with only one of the two groups being reviewed by UHL dermatologists.

When determining the best care model, it is important to also consider how to maximise the utilisation of the hubs. There is evidence that in the first year of the pilot, the hubs had low utilisation. This will have had a significant impact on the cost benefit analysis. Including this within conversations on the best care model for patients, staff and the health system, will enable the greatest potential benefits of the tool. Further analysis of hub utilisation is required to understand current utilisation of hubs and the key drivers.

14.2.3. Possibilities for the future

Out of the post-pilot scenarios, the one where no second reads of benign lesions were undertaken returned the highest benefit-cost ratio. As the pathway is piloted further, ongoing assessments will demonstrate whether this is a viable option, together with alternative delivery models that have been suggested, such as a pre-referral implementation of the AI tool.

The AI model is one that is constantly evolving with improvements made in the software and it is likely that implementing this in teledermatology will require an iterative process between trusts and providers such as SA. As it continues to evolve, re-evaluation will be key to inform effective decision making.

Appendix

Table 1. Hub staff free text responses.

Q7. Do you have any other feedback / comments?	
Respondent 1	*Generally most patients are happy with their appointment. However, there are some that are either wrongly informed about the clinic by their GP or when verbally contacted by the booking team for the clinic. This causes distress to the patients and difficulties for the BAND 2 running the clinic. The equipment provided to capture images has several technical issues, which again, is difficult for those staff running the clinic. GP's are also sending a large number of inappropriate referrals. If all of these issues were addressed and resolved, the clinic is certainly a benefit to UHL and reduces waiting times.* *By the time the patient comes to the clinic, they have struggled to get a GP appointment, to then be sent to this appointment and then be told they may need to attend a further face to face appointment with a Dermatologist. I think the service should be rolled out at General Practitioners Surgeries and then the patient is directed to the appropriate referral from that appointment.*
Respondent 2	*In my opinion there are too many inappropriate referrals coming through to the service. GP practices would benefit from offering this service as the majority of patients could be assessed there and then without the need for a hospital visit. More community hospitals could also offer the service to avoid patients having to travel for what is essentially a triage service. Some then become frustrated that they are not being assessed by a dermatologist.*
Respondent 3	*I think there is still a long way for the service to improve both from the point of the referral from the GP to the booking office*
Respondent 4	*The information shared by GPs needs to be improved as patients often come with different expectations of the service.* *Often the actual equipment is the issue, the camera will not focus to take a clear picture*

Table 2. Clinician free text responses.

Q7. Do you have any other feedback / comments?	
Respondent 1	*My responses to this survey would be more favourable if patients had a photograph taken within 72 hours at a hub close to the patients home address as was originally envisaged.*
Respondent 2	*The interface remains a little clunky with too many steps to approve my report There has been a deterioration in quality of the images submitted to me as the service has rolled out.* *The SA dermatologists appear to be young and relatively inexperienced and very cautious: we have to override their opinion regularly.* *The software's ability to help us easily write a decent reply to the GP needs to be improved.* *I am concerned that the increased numbers of steps to get a F2F with a dermatologist- while beneficial to those with benign lesions- is hindering the access for patients with malignancy.*
Respondent 3	*Until the full evaluation of this pathway is complete, my replies are rather tempered by a lack of data. For me the main benefit of implementing this service is that is allows discharge of 30+% of patients without the need to see a dermatologist and given the workforce issues we face, that is the main benefit. I suspect it is not cost effective compared with the traditional pathway but will await the health economic evaluation. I am yet to be persuaded that we can rely entirely on the AI assessment and until data convinces me otherwise, we need a second read.*
Respondent 4	*Patients with urgent skin malignancies wait 2weeks to have photos taken at Skin Analytics. They then have to wait 2weeks (currently longer waiting times) to see a Dermatologist face to face. They then have to wait 2weeks (currently longer waiting times) to have a biopsy.* *As many lesions cannot be diagnosed with certainty based on photographs, many patients still need a face to face appointment in order to decide on a certain diagnosis and further management.* *Patients also often have more than one skin lesion that need evaluation. As most GP's are still not seeing patients face to face, the only direct clinical contact they have with a physician for a full skin check-up is when they see a Dermatologist face to face. Skin Analytics only evaluate a single lesion and rarely include a second lesion.*
Respondent 5	*It feels very un-nerving when seeing a patient FTF and feeling the lesion is benign when a senior consultant has reviewed the image and feels it could be cancer. I don't like that at all.* *I suspect some lesions if brought in for a FTF review would not require surgery. This strategy means some patients who would benefit from a full skin check don't get it particularly if their BCC/KA is completely excised and discharged.*

Respondent 6	*Many blurred/ out of focus dermoscopy images.* *Has opened the door to lots of benign lesions being referred in where GPs would have previously just had the confidence to see and reassure.* *Yes its quick to whittle out the benign lesions but so many more benign lesions are now being referred so the benefit is lost.* *Quicker to just see patients from the offset rather than doing both for many patients.*