Evaluation of the Teledermatology Service

Evaluation of the Teledermatology service provided by Skin Analytics in Norwich Primary Care Network; April 2019-March 2020

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Abbreviations

AI- Artificial Intelligence

BCC – Basal Cell Carcinoma

DERM – Deep Ensemble for the Recognition of Malignancy

DPC – Data Processing Contract

Eastern AHSN – Eastern Academic Health Science Network

IMD – Index of Multiple Deprivation

NHS NWCCG – NHS Norfolk and Waveney Clinical Commissioning Group

NNUHFT – Norfolk and Norwich University Hospitals NHS Foundation Trust

NSPCCRO – Norfolk and Suffolk Primary and Community Care Research Office

PCN – Primary Care Network

RC – Remote Consultant

SA – Skin Analytics

SCC – Squamous Cell Carcinoma

SC – Secondary Care

TD – Teledermatology

Executive Summary

Evaluation purpose

Teledermatology services allow primary care staff access to a Remote Dermatology Consultant, providing rapid assessment of dermatological lesions. This evaluation aimed to assess the impact of the Skin Analytics provided Teledermatology Service in Norwich PCN, between April 2019 and March 2020.

Methods

We analysed the accuracy of the Remote Consultant care recommendation by accessing patient outcome data from primary care records. We identified the number and type of cancers diagnosed via referrals recommended by the Remote Consultant service to the Norfolk and Norwich University Hospital NHS Foundation Trust. Costs and savings of the service were also considered.

The accuracy of Artificial Intelligence software (DERM AI) to identify lesions which required attention at secondary care was also evaluated.

Finally, we asked primary care staff about their experience of using this Teledermatology Service.

Findings

Accuracy of the Remote Consultant:

We found that the Remote Consultant Service accurately identified lesions which could be managed within primary care, with 0.45% of lesions re-presenting to a GP within six months of the initial referral to the Remote Consultant.

Where the Remote Consultant recommended an urgent referral to secondary care, 65% required treatment or longer-term monitoring. This was reduced to 38% of lesions which were referred on a standard referral.

Cancers were diagnosed in 10% of cases referred to secondary care, whether via an urgent or standard pathway: 23 Basal Cell Carcinomas; 4 melanomas; 1 suspected Squamous Cell Carcinoma.

Costs/savings to commissioners:

Per financial year savings for 2019-20:

- using the service in the 14 practices for which we analysed data: £11,929
- potential savings using the service in all 22 practices in Norwich PCN: £20,426
- potential savings of commissioning the service throughout Norfolk and Waveney CCG: £89,876

Accuracy of the Artificial Intelligence Software:

If the DERM AI software had been used instead of the RC there would have been no impact on patient outcomes in 63% of lesions referred to this Teledermatology service as the lesions would all have been discharged to primary care.

The AI would have impacted the care received by patients where the RC recommended an urgent or standard referral to secondary care, but the AI recommended the same lesions were discharged to primary care. This was the case for 30% of lesions. The AI would not have referred six lesions, which were cancerous and required treatment at secondary care. However, the AI is not licensed for use as a stand-alone diagnostic tool, and all six lesions would have been reviewed by a RC in current usual practice, which acts as a safety net. The likelihood is that the RC would have referred these lesions to secondary care when reviewing.

Primary care staff experience

Staff reported a positive experience of the service, specifically commenting on the swift response time and the ease of use of the equipment.

Conclusions and Recommendations

The Skin Analytic provided Teledermatology service (the Remote Consultant) has clear benefits to patients and the NHS in terms of the speed of assessment and reducing unnecessary secondary care appointments. Teledermatology could support primary and secondary care services to deal with demand, including any COVID related patient backlog.

The use of AI has the potential to further support the NHS, as it develops in the future.

1. Introduction

1.1.   Background

Teledermatology services aim to improve accuracy of diagnosis, reduce inappropriate referrals to secondary care, reduce first outpatient appointments at secondary care, enhance skills in primary care and improve patient experience by providing remote rapid assessments.

The Skin Analytics (SA) provided Teledermatology (TD) service was available to all 22 primary care practices within Norwich Primary Care Network (PCN) between 1st April 2019 and 31st March 2020. The aim of the service was to provide GPs with online access to a rapid dermoscopic diagnosis report by a specialist clinician (Remote Consultant; RC) to assist with diagnosis and advise on next steps for patient care. Reports were provided to referring clinicians within 3 working days.

The TD service would accept images of skin lesions from patients aged 16 and over registered with a GP within the commissioning area (Norwich PCN). Practices were provided with a Nokia 5 camera phone and Dermlite DL1 dermatoscope, as well as all required software to enable the secure upload and transfer of dermoscopic images.

1.2.   Evaluation aim and objectives

Aim:

To assess: the impact of Skin Analytics' TD service in Norwich PCN; the potential impact of Skin Analytics' Artificial Intelligence (AI) software and the potential impact of roll out of Teledermatology across Norfolk and Waveney primary care.

Objectives:

To evaluate the impact of Teledermatology on:

- Referrals to the Dermatology Department at Norfolk and Norwich University Hospital Foundation Trust (NNUHFT) by practices in Norwich PCN who were using Teledermatology compared with those practices in Norwich PCN who were not using Teledermatology in the reporting period
- Accuracy of diagnosis by Skin Analytics RC – did it agree with secondary care?
- Accuracy of diagnosis by Skin Analytics AI
- Conversion rate of referrals at NNUHFT i.e. how many patients referred by the RC received a cancer diagnosis
- Costs of dermatology services to commissioners
- Experience of GPs who have used Teledermatology.

2. Methodology

2.1.   Quantitative data

2.1.1.   Data held in primary care

Of 22 practices within Norwich PCN who were offered the Teledermatology service (Teledermatology practices), data were provided from the primary care databases of 14 who used the service and two who did not (control practices). The service was active between 1st April 2019 – 31st March 2020. Data were collected from practices for the time period 1st April 2019 – 31st October 2020 so that any re-presentations to primary care within six months of the original primary care referral to the RC could be captured and reviewed.

Practices within Norwich PCN were approached to provide anonymous primary and secondary care data to support the evaluation. However, the impact of the COVID-19 pandemic on primary care staff workload during this time meant they were unable to support data collection (with the exception of one practice). To mitigate this, the team arranged Data Processing Contracts (DPCs) between the PCN (*One*Norwich) and individual practices. A Confidentiality Agreement and Letter of Authorisation was then put in place between a member of the evaluation team and *One*Norwich. This enabled the team member to directly access the primary care databases and conduct data collection. All necessary Information Governance structures and policies were adhered to. Appendix A details the data collection templates.

The flow chart in **Figure 1** details the quantitative data available, how exclusions were applied, and the number of patients and lesions analysed in the evaluation.

Norwich PCN
22 Practices

Excluded (n=34 patients)
- 1 practice removed as did not want to participate in the evaluation (n=4)
- Test cases (n=15)
- Images unusable (n=8)
- Other reasons (n=7) (see 2.1.2)

21 Practices

Intervention practices
n=17 practices
n=812 patients
n=987 lesions

Excluded (3 practices)
- No SystmOne Access

14 Practices

AI evaluation:
n=14 practices
Analysed
n=690 lesions

Data not available for 123 lesions (n=117: the patient did not provide consent for AI; n=6 AI detected no/poor image).

RC evaluation:
Analysed
n=14 practices
n=658 patients
n=813 lesions

Control practices
n=4 practices

Excluded (2 practices)
- No SystmOne Access

2 Practices
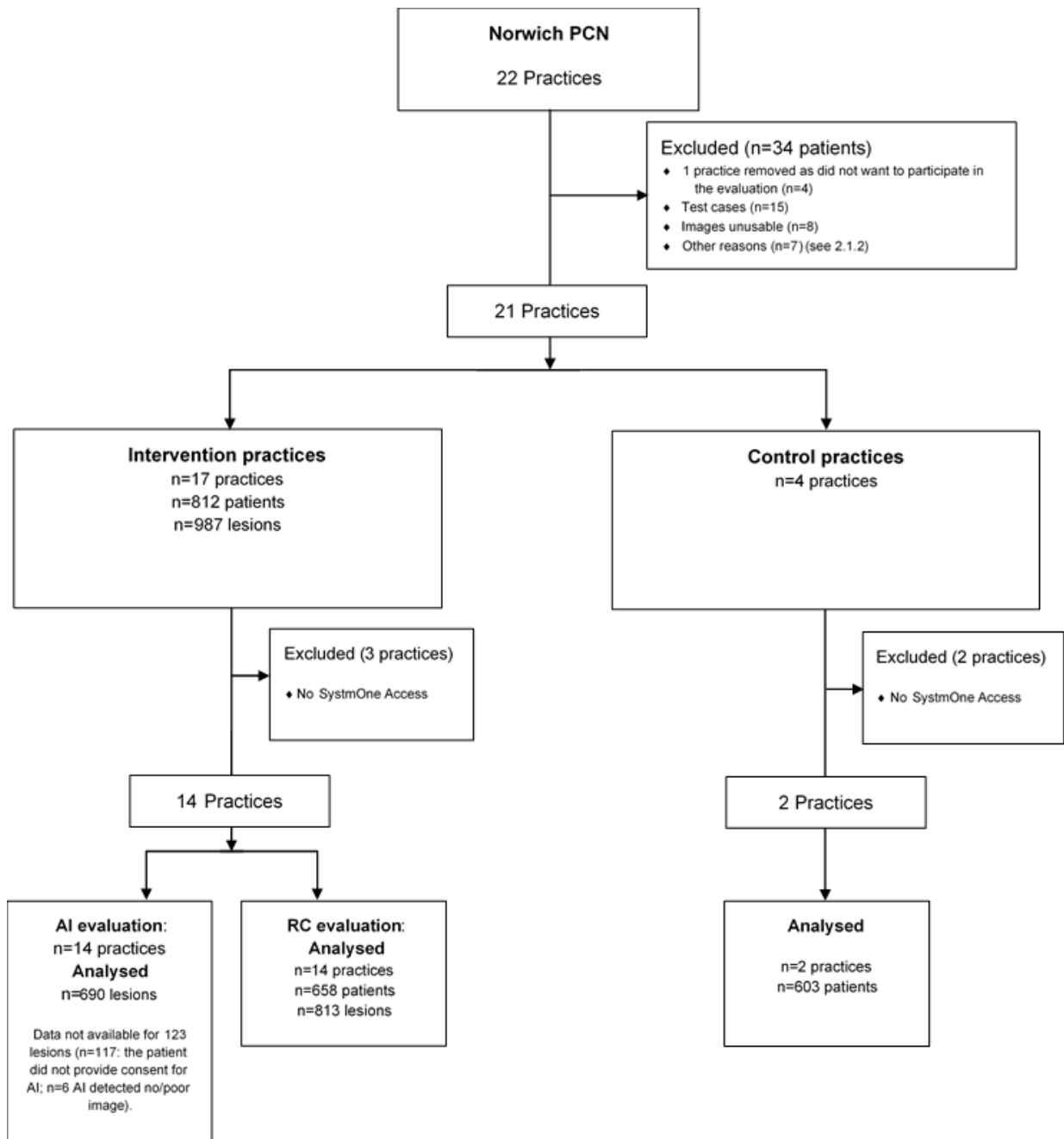
Analysed
n=2 practices
n=603 patients

Figure 1 Flow Chart
Details number of practices, patients and lesions analysed in the evaluation, as well as how exclusions were applied.

2.1.2. Data held by Skin Analytics

Skin Analytics provided data for 846 patients from 18 practices who were referred to the RC between 1st April 2019 and 31st March 2020.

Of these, 34 patients were excluded from the entire analysis. Reasons for exclusion were:

- 15 test cases (image sent to SA as a test of the system);
- 8 where images were unusable;
- 3 where a patient was referred incorrectly;
- 4 where the patient was missing a diagnosis from the RC and/or AI and secondary care;
- 4 patients from a practice which withdrew from the evaluation.

These exclusions resulted in 17 intervention practices with 812 patients. However, access to SytsmOne was not granted for 3 practices within the timeframe so 14 practices were included in the evaluation.

The evaluation is presented in two parts:

- RC evaluation: comparing the RC recommendation with the secondary care assessment in
  - 14 practices
  - 658 patients
  - 813 lesions
- AI evaluation: comparing the accuracy of the AI with both the RC and secondary care assessment in
  - 14 practices
  - 658 patients
  - 690 lesions (see **Figure 1** for exclusions)

In **Appendix C** we present a comparison between the RC and AI data from all 17 practices which referred patients to SA. This is for completeness but no data for secondary care are included in **Appendix C.**

2.2. Qualitative data

We developed an online staff experience survey for completion by primary care staff who had used the RC service. The survey was emailed to all practice managers in the intervention practices who were asked to pass it on to relevant practice staff. The full survey can be found in **Appendix D.**

3. RC evaluation

Findings

3.1. Patient demographics

Table 1 describes the demographics of patients within the 14 practices used for the RC evaluation, 59% were female and the median age was 60 years. Also included is the average quintile for the Index of Multiple Deprivation for the 14 intervention practices.

Demographics	
Number of patients	658
Sex	
Number of Females	388 (59%)
Number of Males	242 (37%)
Data not available	28 (4%)
Number of lesions	813
Age (years)	
Mean	56.4
Median	60.0
Range	18-99
General Practice Index of Multiple Deprivation (mean score)	25.23 (2nd highest quintile of deprivation)

Table 1 Patient Demographics

Number of patients; sex; number of lesions; patient age (mean, median and range); mean Index of Multiple Deprivation (IMD) of practices[1]; n= 14 practices in Norwich PCN using RC.

Table 2 details the patient ethnicity as recorded on primary care records. Over 65% of patients where data were available identified as 'White', 'White British' 'British or mixed British'.

Ethnicity	Patients (%)
White	15.3
White British	35.1
British or mixed British	17.0
English/ ethnic background	0.6
Mixed/ multiple ethnic groups	4.4
Asian or Asian British	0.5
Black, African, Caribbean or Black British	1.2
Other ethnic group	1.7
Data not available*	24.2

Table 2 Patient ethnicity

The percentage of patients identifying as a particular ethnicity within the 14 practices in Norwich PCN (n=658 patients); *data not available: not recorded on notes; error in NHS number.

[1]Public Health Profiles, PHE, 2019; Accessed 24/06/2021.

3.2.   Accuracy of Teledermatology

3.2.1.   Care recommendation by the RC

Of the 14 practices who used the service, a total of 813 lesions (658 patients) were referred by primary care clinicians to the RC. The RC analysed the lesion and provided primary care with a report recommending action for patient care. The patient care recommendations have been categorised as:

1. discharge: where the patient could be managed in primary care;
2. refer – urgent: where the RC termed the referral as 'two- week wait' or 'risk-referral';
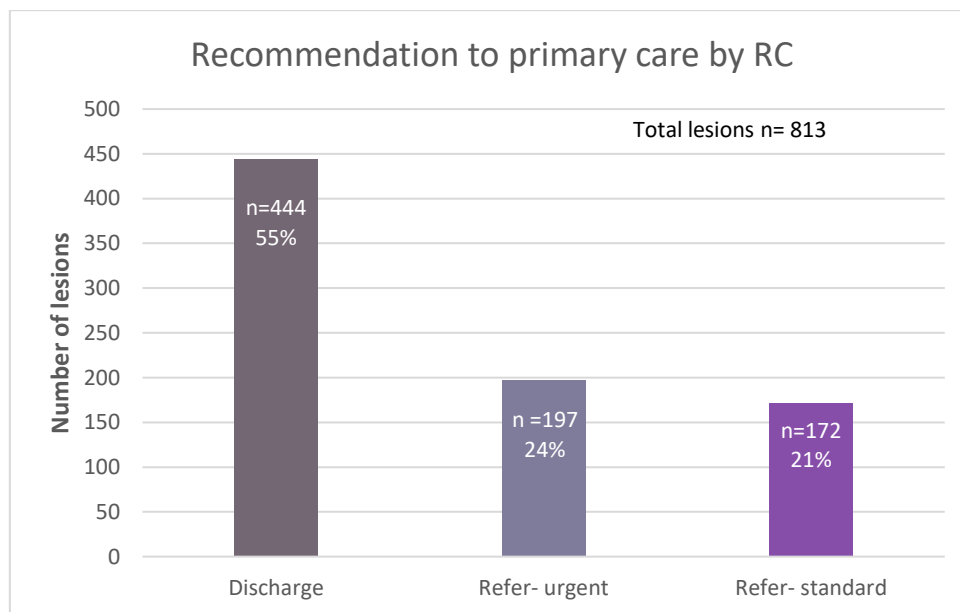3. refer – standard.

Figure 2 *Care recommendation provided by the RC*

The referring primary care clinician was provided with a care recommendation from the RC, categorised as: discharge (n=444); refer-urgent (n=197); refer standard (n=172). Data are presented as number of lesions to reflect that patients were referred to the RC to with up to three lesions in one referral; n=14 practices, n=813 lesions, n=658 patients.

The RC recommended that 444 of 813 (55%) lesions were discharged to primary care, that 197 were referred on an urgent referral to secondary care (24%) and that 172 (21%) were referred on a standard waiting time pathway (62 days) (**Figure 2**).

3.2.2.   Re-presentation at primary care

To determine the accuracy of the RC recommendation for the 'discharge' patients we examined primary care data to identify if any of these patients had re-presented to primary care within six months of the original RC referral. Twenty patients re-presented with issues concerning 25 lesions, 0.45% of the number discharged. Of these, one lesion was subsequently referred to secondary care on an urgent referral where excisions were performed for haemangiomas. No re-presentations were because a lesion had become malignant. Full details can be found in **Appendix E.**

3.2.3. Secondary care outcomes for patients where referral was recommended by RC

To further investigate the accuracy of the RC care recommendations, we examined primary care data to identify the outcome at secondary care. We were unable to access secondary care outcome data for lesions where 29 urgent referrals and 66 standard referrals were made because:

- the patient had not yet been seen in secondary care;
- data from secondary care were not present on primary care records as they had moved out of area or were now deceased;
- an error was identified in the NHS number;
- impact of COVID on secondary care appointment availability.

These have been removed from the analysis and are not presented in **Figure 3** or **Figure 4**.

3.2.4. Urgent referral recommended

The RC recommended an urgent referral to secondary care for 168 lesions; outcomes are detailed in **Figure 3**.

Figure 3 *Patient outcomes at secondary care following an urgent referral recommendation by the RC*
Where the RC recommendation was to refer to secondary care on an urgent referral, outcomes at secondary care were categorised as: treated (n=92); discharged at secondary care (n=58); monitored (n=17); did not attend (n=1). Data are presented as number of lesions (total n=168) to reflect that patients were referred to the RC to with up to three lesions in one referral.

Of those referred to secondary care on an urgent referral where data were available, 92 (55%) required treatment, 58 (35%) were discharged following their appointment and 17 (10%) were monitored. In one case a patient did not attend their secondary care appointment (**Figure 3**).

Where treatment was required, four lesions were diagnosed as malignant melanomas and 11 were Basal Cell Carcinomas. The remaining 77 lesions were benign.

Patients who were discharged from secondary care were all diagnosed with benign lesions (n=58 lesions). One of these patients re-presented at primary care and received topical treatment whilst waiting for a secondary care appointment.

Monitoring was in place for 17 lesions where there was a possibility the lesion could develop into a malignant melanoma.

3.2.5. Standard referral recommended

Of those lesions referred to secondary care on a standard referral where data were available (total n=106), 40 required treatment, 61 were discharged following their appointment and 1 was monitored (**Figure 4**).
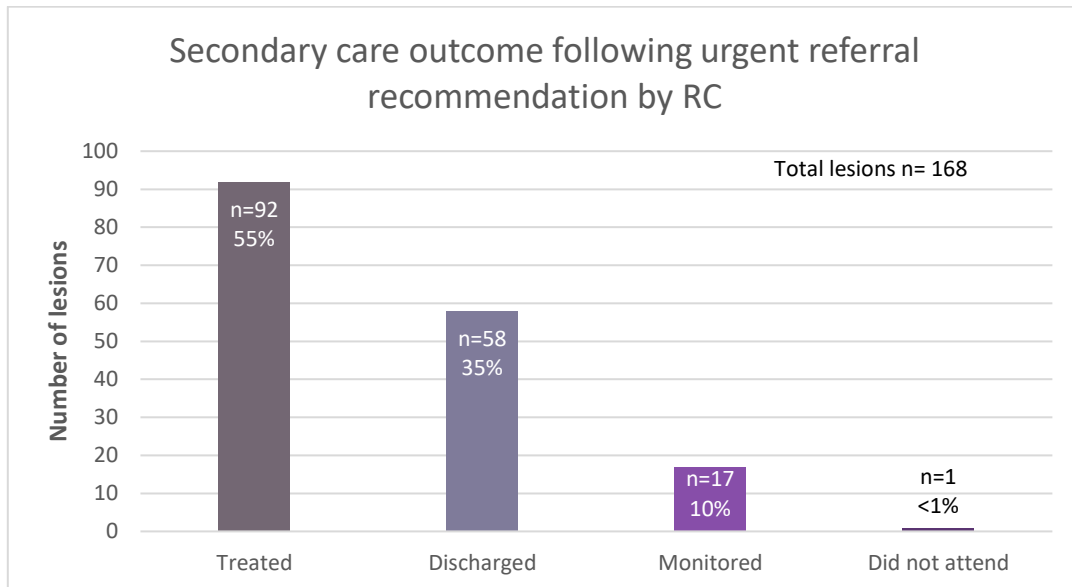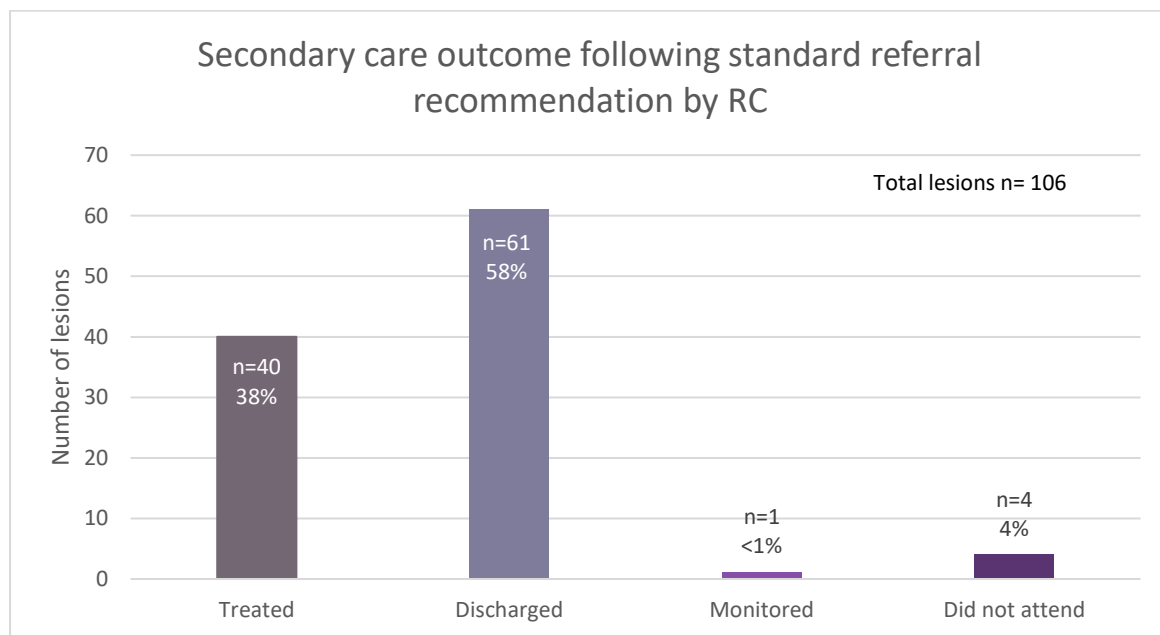

Figure 4 *Patient outcomes at secondary care following a standard referral recommendation by the RC*
Where the RC recommendation was to refer to secondary care on standard referral outcomes at secondary care were categorised as: treated (n=40); discharged at secondary care (n=61); monitored (n=1); did not attend (n=4). Data are presented as number of lesions (total n=106) to reflect that patients were referred to the RC to with up to three lesions in one referral.

In the case of four lesions, patient(s) did not attend.

Where treatment was required, 11 lesions were Basal Cell Carcinomas with one suspected Squamous Cell Carcinoma. The remaining 28 lesions were benign.

Of the discharged cases, all but one were diagnosed as benign lesions (n=60) and one was a low risk Basal Cell Carcinoma which was treated at the first outpatient appointment and discharged. Of these there were two re-presentations at primary care, both have been referred back to secondary care.

One patient was monitored to exclude potential malignancy if the lesion changes.

3.3. Cancer diagnoses following a secondary care referral recommendation by RC

The RC recommended that a total of 274 lesions were referred to secondary care, resulting in a diagnosis of cancer in 28 cases (10%). Fifteen of the 28 diagnosed cancers were as a result

of a referral on an urgent pathway and 13 were as a result of a referral on the standard pathway (**Figure 5**).

Figure 5 Cancer diagnoses resulting from a referral to secondary care by the RC
The RC recommended that n=274 lesions were referred to secondary care with 28 (10%) resulting in a cancer diagnosis. 168 lesions were referred on an urgent referral resulting in 15 diagnoses (9% of urgent referrals) and 106 on a standard referral resulting in 13 diagnoses (12% of standard referrals). Data are presented as number of lesions to reflect that patients were referred to the RC to with up to three lesions in one referral; n=14 practices.

The most common type of cancer diagnosed at secondary care following a referral recommendation by the RC was a Basal Cell Carcinoma (BCC), with 11 diagnosed from urgent referrals and 12 from standard referrals (**Figure 6**). Four lesions were diagnosed as melanomas from urgent referrals and one suspected Squamous Cell Carcinoma was diagnosed from a standard referral (**Figure 6**).

Figure 6 *Number and type of cancer diagnosed at secondary care following a referral recommended by the RC*
Basal Cell Carcinoma (BCC) was diagnosed in 11 of the 28 urgent referrals and 12 of the 23 standard referrals. Melanomas were diagnosed in 4 of the 15 urgent referrals and one suspected Squamous Cell Carcinoma (SCC) was diagnosed from a standard referral.

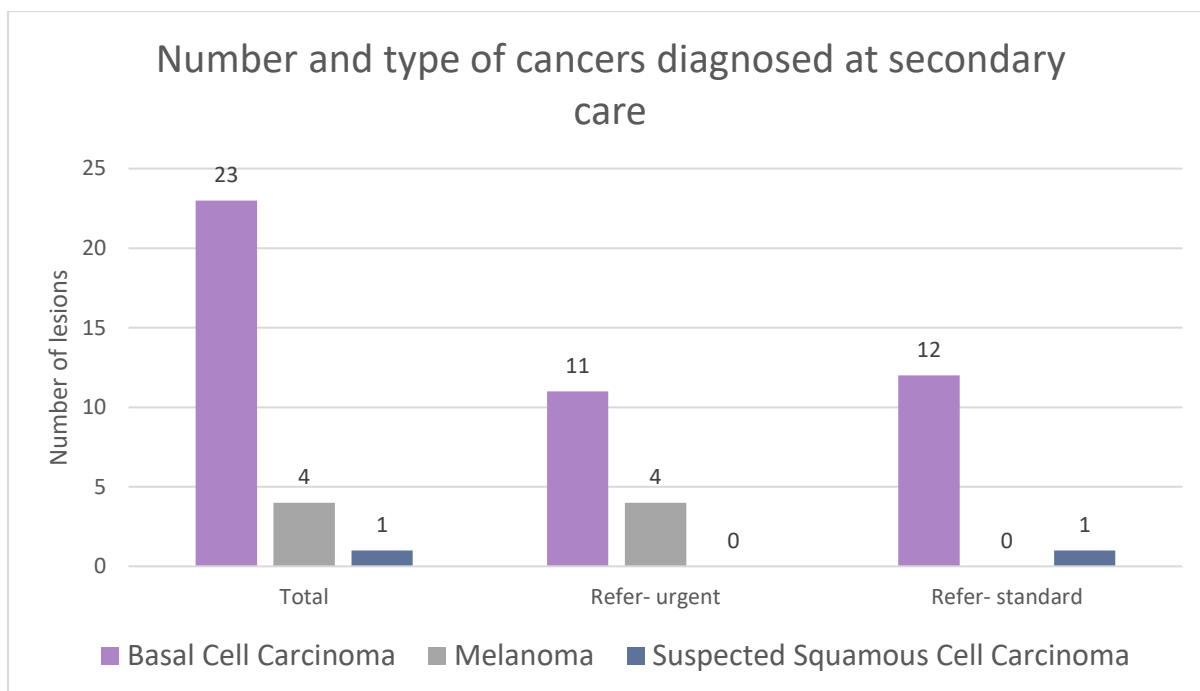## 3.4. Implications for commissioning the RC service

3.4.1. Cost of service

To determine the implications of commissioning a TD service we considered:

- the cost of a primary care appointment in 2019: £28[2]
- total cost of referring one patient to Teledermatology: £40.10[3] (includes fee per referred case; cost of equipment provided; training of primary care staff; cost of CCG support staff).
- the cost of a referral to secondary care for first outpatient appointment at dermatology with a single healthcare professional in 2019/20: £125[4].

3.4.2. Impact of RC on costs to commissioners- Norwich PCN

Using the figures in section 3.4.1 and the data in section 3.2 we estimated the costs and any savings to commissioners. Where the RC care recommendations were followed in the 14 practices, 444 fewer lesions were referred for a first outpatient appointment at secondary care. As multiple lesions could be seen at one appointment, costs are calculated on a per

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[2] Curtis, L. & Burns, A. (2019) Unit Costs of Health and Social Care 2019, Personal Social Services Research Unit, University of Kent, Canterbury DOI: 10.22024/UniKent/01.02.79286; Unit cost of 9.2min GP consultation excluding direct care staff costs and qualification costs
[3] Skin Analytics Health Economic Evaluation, 2021; provided by Skin Analytics.
[4] 2019/20 National Tariff Payment System: national prices and prices for emergency care services; available from https://www.england.nhs.uk/publication/past-national-tariffs-documents-and-policies/ ; accessed 19/06/2021

patient basis, not a per lesion basis. There were 658 patients referred to the RC, 317 of which the RC recommended were subsequently discharged to primary care.

Taking into account the cost of the RC service, and the number of referrals recommended by the RC to secondary care, there are savings of **£11,929 (Table 3).**

	No RC service: all referrals direct to SC	*RC service:* actual referrals to RC	*RC service:* actual referrals to SC	*RC service:* RC referrals re-presenting to PC within six months (no initial SC referral)	*RC service:* RC referrals that re-presented to PC and then went to SC (no initial SC referral)
Number of patients	658	658	341	20	6
Cost of RC @ £40.10		£26,386			
Cost of PC @£28				£560	
Cost of SC @ £125	£82,250		£42,625		£750
SAVINGS	**£11,929**				

Table 3 Costs and savings to commissioners for 14 practices where secondary care data were available

3.4.3. Potential impact of RC on costs to commissioners- Norfolk and Waveney wide

In order to try and understand the potential impact of commissioning this Teledermatology service throughout Norfolk and Waveney CCG we have had to make a number of assumptions, based on the following:

- we have RC data for 14 of 22 practices in Norwich PCN, representing 60% of the patients in Norwich PCN
- the number of patients in the 14 practices is approximately 146,000
- the total number of patients in Norwich PCN is approximately 250,000
- the total population of Norfolk and Waveney CCG is approximately 1.1 million[5]

Using these assumptions, the potential savings, per financial year (based on costs in 2019/20), of using this service would be:

- for all practices in Norwich PCN: £20,426
- for all practices in Norfolk and Waveney CCG: £89,876

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[5] www.norfolkandwaveneyccg.nhs.uk/about-us; accessed 29/06/2021

3.5. Potential impact of the RC on referrals to NNUHFT from control practices

The evaluation team compiled a list of 41 READ codes for which SA confirmed they received referrals from primary care (**Appendix B).** The primary care databases of 13 of 14 practices in the RC evaluation (one practice had removed S1 access) were searched to identify how many patients with those READ codes were seen at each practice during the reporting period (**Table 4**). We then identified the number of patients with these READ codes who were referred to the RC in the intervention practices (**Table 4**).

		Number of patients referred to RC (n=)	Patients referred to RC (%)
All referrals to RC (n=13 practices)	Mean	47	21%
	Median	46	9%
	Range	3-166	1-86%
referrals to RC excluding outlier (identified using Interquartile range; n=12 practices remaining)	Mean	37	15%
	Median	41	9%
	Range	n=3-73	1-40%

Table 4 *Referrals to the RC from intervention practices with 41 READ codes*
n=12-13 practices.

An average of 21% of patients presenting at primary care with the relevant READ codes were referred to the RC. As the range was between 1-86% of patients we identified outliers using Tukey's method[6] which uses the interquartile range. We removed one data point. This reduced the mean number of referrals to the RC to 15%.

At the practice where 86% of cases were referred to the RC it may be that staff require more training to become confident in differentiating between cases they could manage in primary care or needed referral to secondary care. Where referrals to the RC were particularly low the RC service may have benefited from more promotion or it may be that staff were particularly confident in their ability to diagnose dermatological conditions. We were unable to explore these possibilities in this evaluation.

To estimate the impact of the RC on referrals from primary care to secondary care in the control practices the same READ codes were searched for in the 2 control practices. A total of 603 patients were identified using these READ codes.

Based on the average number of patients referred to the RC in the intervention practices (15-21%), assumptions were then made on the likely impact of the RC on patient referrals to secondary care had the control practices used the RC service.

A mean of 15-21% of patients presenting to primary care with at least one of the 41 READ codes were referred to the RC (**Table 4**). Of these the RC recommended 45% were referred to secondary care on an urgent or standard referral. Using these figures as best assumptions of the impact of the RC on referrals to secondary care we estimate that:

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[6]Introduction to Robust Estimation and Hypothesis Testing in Statistical Method and Decision Science, 2017, pages 45-106; https://doi.org/10.1016/B978-0-12-804733-0.00003-2

- 90-127 patients in control practices would have been referred to the RC instead of directly to secondary care, saving between £7,641-£10,782 on the initial appointment;
- Of these, an average of 45% (n= 41-57) would have been referred to secondary care by the RC on an urgent or standard referral (**Figure 2**) at a cost of £4,125-£7,125;
- The remaining 55% (n=49-70) would have been discharged to primary care (**Figure 2**).

We were unable to identify the exact outcomes for the 79-85% of patients in the control practices who would not have been referred to the RC. Patients would either have been referred directly secondary care or treated within primary care.

3.6.   Primary care staff experience

We received five responses to the online primary care staff experience survey (**Appendix D**). Not all respondents answered every question.

Respondents commented that:

- the equipment was easy to use and the built-in measurement on the dermoscope was very useful
- the referral process was convenient, quick and easy
- they were pleased with the speed at which a decisive response to referrals was provided
- they liked the fact they could access a copy of the report with the photos on SystmOne
- there were two comments expressing their displeasure that the service had been discontinued

One respondent commented that they much preferred the SA provided service over the two services which have subsequently been commissioned, finding the SA service simpler and less time consuming.

Of the three replies to the question asking about least good aspects of the service, two replied that there were none, whilst one queried the cost implications of the service.

Four of the five respondents said they were very likely to recommend the service and the other respondent said they were likely to.

Conclusions and recommendations

3.7.   RC Teledermatology services

This evaluation considered the impact of the Skin Analytics provide Teledermatology Service in Norwich PCN between April 2019 and March 2020.

Data presented in this report support the commissioning of this RC service. 55% of lesions were discharged immediately to primary care following an assessment by the RC, with just 0.45% of lesions re-presenting to primary care within six months of the initial referral to the RC. This has a tangible impact on footfall at secondary care dermatology services with limited negative impact on patient outcomes.

Although responses to the qualitative survey were minimal, the themes arising from them were consistent. The speed, ease and quality of the RC service were all praised.

Deployment of a RC service has the potential for very quick wins across the health and care system in terms of patient outcomes, footfall at secondary care, savings to the system and the potential to significantly support the clearance of any backlog resulting from Covid-19.

When a service is commissioned, regular monitoring of the number of referrals within each practice should be carried out. We found there was a wide range across the 14 practices (1-86%) of referrals suggesting that ongoing education and support for practices in using the RC service may be welcome to ensure the NHS and patients receive the best outcomes for the investment.

4.0 AI evaluation

Findings

4.1.   Accuracy of AI

Skin Analytics have developed a machine learning algorithm (Deep Ensemble for the Recognition of Malignancy; DERM), an AI solution built to recognise the most common malignant, pre-malignant and benign skin lesions. This analysis has been carried out using the latest available version of DERM which was Version 3 (Version 3 available June 2021). This would not have been available at the time the TD service was active in 2019/20 in Norwich PCN.

Of the 14 practices where we were able to access secondary care data, patients provided consent for 696 of the 813 lesions to be analysed by AI. Six images were not able to be processed by the AI (the AI detected no lesion image, or the image was of bad quality). Of the remaining 690 lesions we have compared the recommendation made by the RC with that made by the DERM AI tool.

The DERM AI agreed with the RC recommendation (to discharge, urgent-refer or standard-refer) in 434 lesions and disagreed with the RC recommendation in 256 lesions (**Figure 7**).

Figure 7 *Comparison between the RC and DERM AI care recommendations*
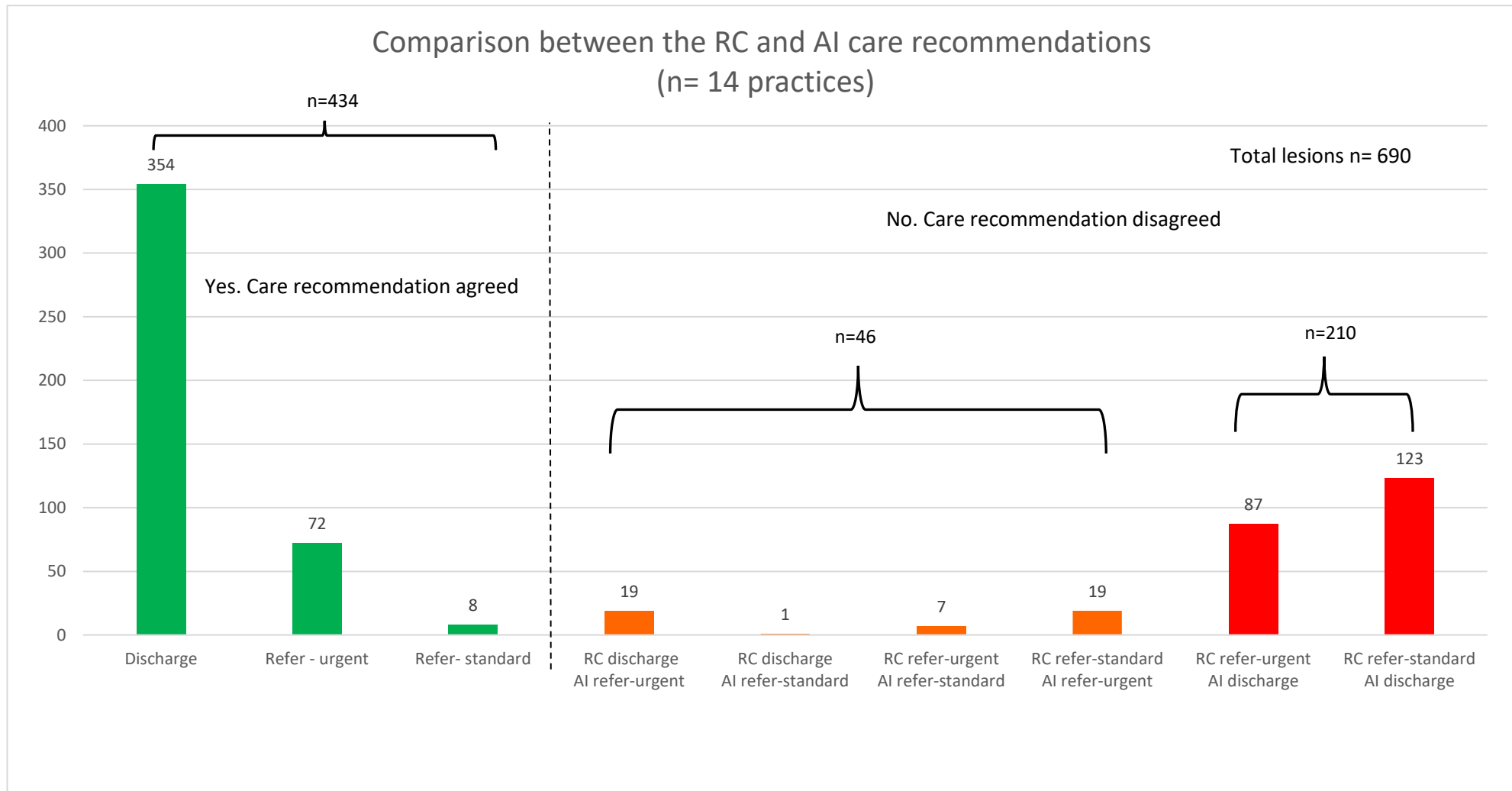The RC and AI agreed on the care recommendations for n=434 lesions and disagreed for in the case of n=256 lesions. In n=46 lesions this would have no impact on patient care outcomes. We could assess the potential care outcomes for n=210 lesions, where AI recommended discharge at primary care and RC recommended an urgent or standard referral to secondary care.

4.1.1. Potential Impact of AI on patient outcomes

For this section we are using lesions, rather than the number of patient appointments.

We considered the impact of the AI care recommendation as if primary care had used the AI recommendations instead of the RC. In 434 of 690 lesions (63%) the RC and the AI agreed (**Figure 7**, green bars), this would have had no impact on patient outcomes.

There would also have been no impact on patient outcomes if the AI care recommendation was more cautious than the RC. This was the case for 20 lesions where the RC recommended to discharge at primary care but the AI recommended a standard (n=1) or urgent referral (n=19) (orange bars, **Figure 7**). These outcomes would have resulted in an additional 20 secondary care first outpatient appointments at an additional cost of £2,500 (see section 3.4). However, we know that two of these lesions re-presented to primary care with a subsequent referral to secondary care.

There would have been limited impact on patient outcomes for 7 lesions where the RC recommended an urgent referral and the AI a standard referral (n=7, orange bars, **Figure 7**. This is also the case where the RC recommended a standard referral and the AI recommended an urgent referral (n=19, orange bars, **Figure 7**). There would also be no immediate cost implications of these AI recommendations.

We investigated the patient outcomes at secondary care for the 87 lesions where the RC advised an urgent referral but the AI recommended the lesions were discharged in primary care (**Figure 7**, **Table 5**), as these had the potential to alter patient outcomes.

Outcome at secondary care	Number of lesions
Treated	38 (n=1 Basal Cell Carcinoma, n=37 benign lesions)
Discharged	34
Monitored	4
Did not attend	0
No data*	11
Total	87

Table 5 Secondary care outcome of lesions where AI recommended discharge in primary care and RC advised an urgent referral

Total lesions n=87. *No data: n= 11 lesions (data from secondary care was not present on primary care records as the patient had moved out of area (affecting 6 lesions); or had now deceased (1 patient/lesion); n=3 errors were identified in the NHS number; n= 1, SA did not provide patient data.

Of the 38 lesions which required treatment at secondary care (**Table 5**), one lesion was diagnosed as a Basal Cell Carcinoma. Thirty-four lesions were discharged at secondary care as the lesions were benign and did not require treatment. Had the AI been in use, there was the potential for savings on 34 outpatient appointments at a total cost of £4,250. The benefits of this saving must be weighed up against the needs of the 38 patients who required treatment but would not have been referred to secondary care, and who may have re-presented at primary care with the same lesion (cost of £1,064 at £28 per primary care appointment) and with the potential need for more urgent treatment.

Of those referred by the RC, four lesions were monitored as they had potential to develop into malignant melanomas. If the AI were in place, these patients would not be under the care of the dermatology team and may have re-presented to primary care with worse symptoms requiring urgent attention.

No data were available for eleven lesions.

In 123 cases the AI recommended discharge at primary care where the RC advised a standard referral. We investigated the secondary care outcomes of these lesions (**Table 6**).

Outcome at secondary care	Number of lesions
Treated	24 (n=5 Basal Cell Carcinomas; n= 19 benign lesions)
Discharged	50
Monitored	1
Did not attend	2
No data*	46
Total	123

Table 6 Secondary care outcome of lesions where AI recommended discharge in primary care and RC advised a standard referral

Total lesions n=123. *No data n=46 lesions data from secondary care was not present on primary care records as the patient had moved out of area (affecting n=5 lesions;) or had now deceased (affecting n=2 lesions); n=3 errors were identified in the NHS number; n=3 lesions not referred-decided to monitor in primary care; n=5 lesions no longer require care (n=1 case NNUH rejected referral and advised mole was a benign naevus); n=26 lesions had not yet been seen in secondary care; n=2 no secondary care information in patient notes.

Of the twenty-four lesions which required treatment at secondary care (**Table 6**) five were diagnosed and required treatment for Basal Cell Carcinomas. Fifty lesions were discharged at secondary care whilst one was monitored for likely dermatofibroma. Had the AI been in use there was the potential for savings on 50 outpatient appointments at a total cost of £6,250.

The benefits of this saving must be weighed up against the needs of the 24 patients who required treatment but would not have been referred to secondary care, including the impact of missing five cancer diagnoses for the patient and the NHS.

No secondary care data were available from primary care records for 46 patients.

In one case, the RC recommended discharge to primary care but the DERM AI recommended a standard referral. This patient did not re-present with their lesion within 6 months of referral to TD for the same dermatology issue, with a potential saving of £125.

Had patients been referred to a TD service using the most up to date version of the SA DERM AI tool, a further 20 lesions would have been referred to secondary care and 210 lesions discharged at primary care (**Table 7**). The AI care recommendation could be considered accurate for 84 of these lesions, as they did not require treatment in secondary care and were subsequently discharged. 69 of the lesions required treatment at secondary care and would not have been referred if the AI were in use in place of the RC, of these 69, 6 were cancers (**Table 7**): all were Basal Cell Carcinomas.

Potential impact of AI care recommendation	
Additional lesions AI referred to secondary care	20
Number of lesions AI discharged at primary care	210
Number of lesions where secondary care data are unavailable	57/210
Number of lesions AI discharged at primary care where secondary care data are available	153/210
Number of lesions discharged at primary care by AI where actual secondary care outcome was **no treatment required**	84/153 (55%)
Number of lesions discharged at primary care by AI when where actual secondary care outcome was that **treatment was required**	69/153 (45%)
Number of cancers which would not have been referred to secondary care	6 (all Basal Cell Carcinomas)

Table 7 Potential impact of AI on outcomes

The use of AI would have reduced secondary care referrals by 190 compared to the RC, decreasing footfall at NNUHFT. However, this reduction in footfall could have negatively impacted on patient outcomes. An estimated 55% of lesions that required treatment would not have received treatment at this time. Six of these lesions were diagnosed as cancers.

It is likely that the use of this version of DERM AI would have negatively impacted on GP time on the assumption that the 55% of lesions discharged would have re-presented at primary care.

Conclusions and recommendations

4.2.   Skin Analytics provided AI service

Comparing the recommendations of the DERM AI version 3 with the actual recommendations of the RC and the secondary care outcomes of patients referred by the RC, yielded interesting results.

There was considerable agreement between the AI and the RC in terms of lesions which should be discharged to primary care (63%; 434/690 lesions; **Figure 7**). The AI also recommended that 69 lesions be discharged to primary care when compared with the original RC recommendations with a reduction in the number of benign lesions referred to secondary care. Had the AI been in place this reduction would have resulted in increased savings to the system.

We also found that six cancers (BCCs) which required treatment would not have been referred by the AI.

So, although there would have been an initial benefit in reducing footfall to secondary care, in terms of supporting the time taken to clear any COVID pandemic induced back-log, it is important to consider that patient symptoms could worsen over time, and a later referral could lead to worse patient outcomes coupled with more expensive and intensive treatment, along with the potential to negatively impact on patient experience and perhaps support for the use of new technologies in future.

There are some caveats to the above discussion points as the evaluation of the AI in this report does not reflect the current real-world situation. Firstly, the camera phone used to

take images of the lesions in primary care was a Nokia 5: this is not approved for use with DERM v3, so there may be an issue in terms of the quality of the image the AI was analysing.

Secondly, DERM AI is currently licensed by the MHRA as a Class I Medical Device so if deployed in a real-life setting DERM would be used as a decision support tool for qualified clinicians.

In addition to this in the early deployments a RC review would have taken place where the AI did not identify a melanoma, squamous cell carcinoma, BCC, Bowen's disease or atypical naevus, as a safety net. It is therefore possible that the six BCCs which were not picked up by the AI would have been identified in this way and a recommendation to refer to secondary care would have been made.

In considering the deployment of AI within such remote dermatology services, commissioners should weigh up the balance of a reduction in footfall to secondary care with the impact of missing cancer diagnoses and the longer-term impact of this on patients and the NHS.

5.0 Funding and Acknowledgements

6.0 Appendices

Appendix A

6.1 Data collection templates

Data collection template A – Skin Analytics to complete for patients where Teledermatology was used (collects information on the Teledermatologist and DERM AI report):

Template%20A%20FI
NAL.xlsx

Data collection template B – Skin Analytics and primary care to complete for patients referred by the Teledermatology service to secondary care (collects information on patient demographics, their secondary care outcomes/diagnoses data and whether they re-presented to primary care within 6 months of referral to TD for same dermatology issue):

Template%20B%20FI
NAL.xlsx

Data collection template C – Skin Analytics and primary care to complete for patients discharged by the Teledermatology service (collects information on patient demographics and whether they re-presented to primary care within 6 months of referral to TD for same dermatology issue):

Template%20C%20FI
NAL.xlsx

Data collection template D – Primary care data collection for the practices which did not use the Teledermatology service (collects demographic information following a search for patients who presented to primary care between 01/04/2019 and 31/03/2020 with a list of 41 READ codes):

Template%20D%20FI
NAL.xlsx

Appendix B

6.2 READ codes- reasons why primary care referred to RC

Reason	READ code
Fast track referral for suspected skin cancer	276281000000104
Malignant melancytic lesion (malignant melanoma - category)	372156000
Malignant Melanoma of skin	93655004
Melanoma in situ in skin	109266006
Squamous cell carcinoma	28899001
Squamous cell carcinoma in situ	59529006
Squamous cell carcinoma of skin	254651007
Basal cell carcinoma	1338007
Excision of basal cell carcinoma	300025007
Basal cell carcinoma of skin	254701007
Basal cell carcinoma, infiltrative	56665009
Cryotherapy of basal cell carcinoma	300026008
Multifocal superficial basal cell carcinoma	61098004
Basosquamous carcinoma	37304002
Basal cell carcinoma, fibroepithelial	43369006
Basal cell carcinoma, nodular	128636006
Actinic keratosis	201101007
Cryotherapy of actinic keratosis	445111008
Actinic cheilitis	46795000
Bowen's disease	84999002
Intraepithelial squamous cell carcinoma	400066006
Melanocytic naevus of skin	400010006
Pigmented Naevus	21119008
Benign naevus of sole of foot	312359004
Senile hyperkeratosis	398838000
Irritated basal cell papilloma	254668006
SK of eyelid	231826004
Melanocanthoma	394727000
Haemangioma	400210000
Haemangioma	2099007
Vascular neoplasm of skin	400132000
Benign haemangioma	253053003
Malignant haemangioma	253052008
Dermoid cyst	123151001
Epidermoid cyst of skin	419603000
Ruptured epidermal cyst	254673000
Verruca vulgaris	57019003
Histiocytoma	302843004
Dermatofibrosarcoma	76594008
Dermatofibrosarcoma protuberans	276799004
Excision of dermatofibroma	700074001

Appendix C

6.3 Comparison of RC and AI for 17 practices in Norwich PCN

In total, 17 practices within Norwich PCN accessed the RC service, however only 14 practices provided the team with access to primary care records so we could collect secondary care data.

SA have provided the evaluation team with the RC recommendations for 812 patients with 987 lesions registered at all 17 practices. Of these SA had consent from patients to run the AI software on 846 lesions. We compared the RC care recommendation with the AI care recommendation and the results are presented in **Figure 8**.

The RC and AI agreed in 526 lesions so there would have been no impact on patient care had the AI been used instead of the RC (green bars, **Figure 8**).

There would have been limited negative impact on patient care for 65 lesions where the AI was more cautious than the RC, recommending referrals to secondary care either instead of the RC recommendation to discharge or a more urgent referral than the RC suggested (orange bars, **Figure 8**).

For 255 lesions the AI was less cautious than the RC, recommending with discharge to primary care rather than an urgent (n=104 lesions) or a standard referral (n=151 lesions) (red bars, **Figure 8**). There is the potential that patients may have missed out on treatment. We know from section 4.1.1, **Figure 7** and **Table 8** that an extra 17 patients would not have had an urgent referral and 28 patients would not have had a standard referral to secondary care.

	RC urgent referral, AI discharge to primary care (number of lesions)	RC standard referral, AI discharge to primary care (number of lesions)
N=17 practices	104	151
N= 14 practices	87	123
Number of additional lesions which may have needed secondary care treatment had AI been in use	17	28

Table 8 Additional lesions which would not have been referred to SC if AI had been in use at all 17 intervention practices
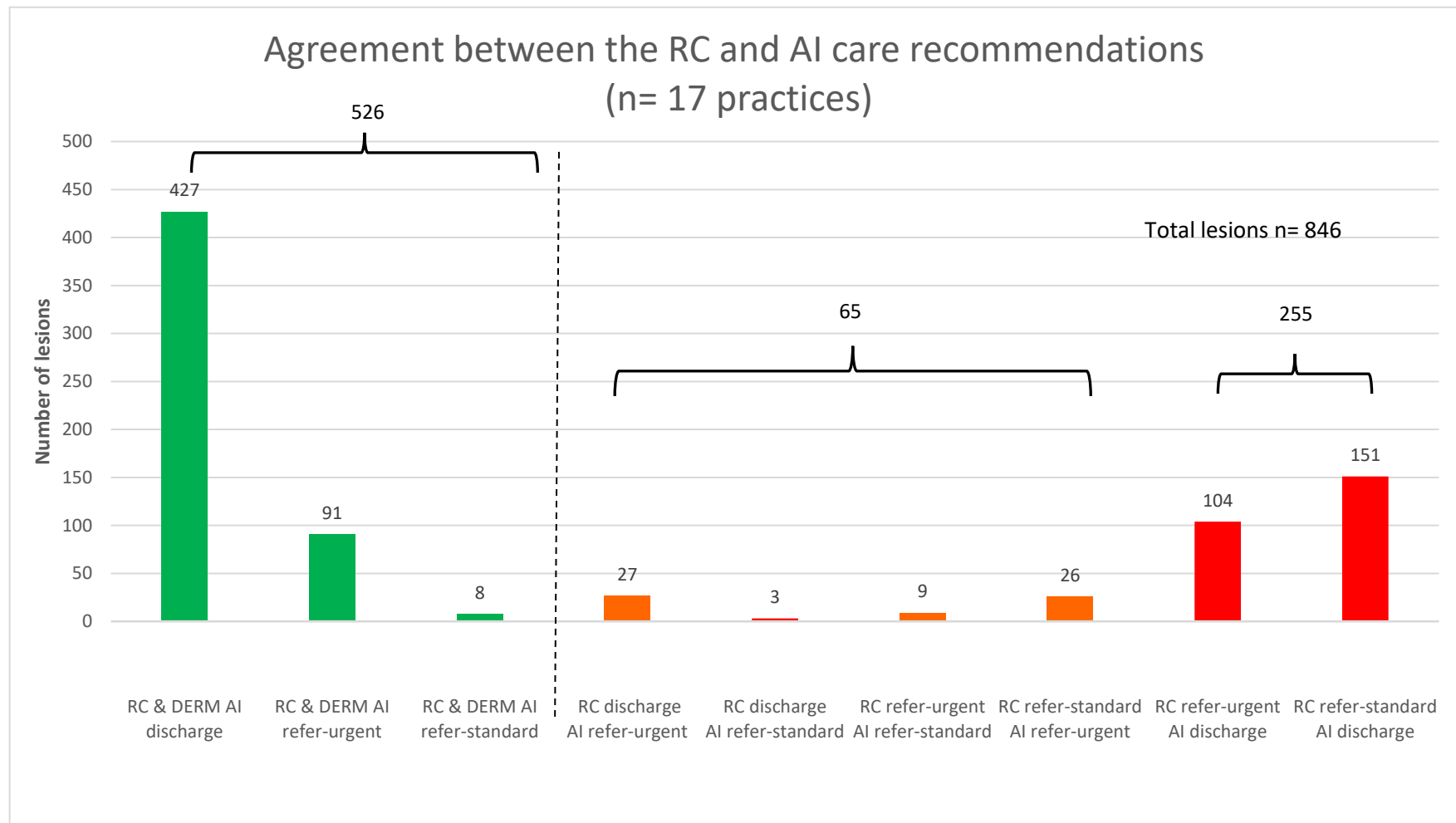
Figure 8 *Comparison between the RC and DERM AI care recommendations* at 17 intervention practices

The RC and AI agreed on the care recommendations for n=526 lesions and disagreed for in the case of 320 lesions. In n=65 lesions this would have no impact on patient care outcomes. There was the potential to impact the care outcomes for n=255 lesions, where AI recommended discharge at primary care and RC recommended an urgent or standard referral to secondary care (red bars).

Appendix D

Primary care staff who referred patients to the RC were asked to complete a qualitative survey comprising the following items:

1.   What were the best aspects of the remote consultant service? Please feel free to say as much as you want.

2.   What were the least good aspects of the remote consultant service? Please feel free to say as much as you want.

3.   How likely are you to recommend the Teledermatology service to another practice?

Very Likely ☐ Fairly Likely ☐   Neutral ☐   Unlikely ☐   Very Unlikely ☐

4.   Is there anything else you'd like to tell us? Please feel free to say as much as you want.

Appendix E

6.5 Reasons for patients re-presenting at primary care

Number of lesions (Number of patients)	Reason for re-presentation at primary care	Intervention and outcome in primary care	Intervention and outcome at secondary care
7 (5)	Enquiry about lesion removal for symptomatic relief.	Consultation; lesion removal	n/a
8 (6)	Patient concerned by a change to lesion/not clearing.	n=3 lesions (2 patients): reassured by GP; n=1 lesion: prescribed topical treatment; n=2 lesions (1 patient): urgent referral; n=2 lesions (2 patients): intervention at secondary care (phone consultation, standard referral)	n=2 lesions (1 patient): urgent referral: excisions performed: haemangiomas; n=1 lesion: phone consultation with NNUHFT, patient self-monitoring agreed; n=1 lesion: standard referral: letter to expedite appointment: further lesions: seborrhoeic keratoses / solar keratoses.
2 (2)	Presented with symptomatic seborrhoeic keratosis lesions	Prescribed topical treatment	n/a
3 (3)	Patient requesting referral to secondary care (NHS and private provider)	Referrals made	n=2 lesions/patients: private referrals (for lesion removal, reassurance/review) n=1 lesion: standard referral (NNUHFT: refused referral as: did not meet referral criteria; pressure on service; advised topical treatment)
3 (3)	Topical treatment review Review of topical treatment for keratosis	n=1 lesion: standard referral due to persistent seborrhoeic keratosis symptoms	Diagnosis of chondrodermatitis nodularis helicis: patient given topical treatment, if this does not resolve, patient to book in for a review appointment.

| 2 (1) | Consultation about RC recommendations | GP reassured lesions were harmless. | n/a |

Table 9 *Reasons patients re-presented at primary within six months of the initial referral to the RC*