Service Evaluation of Three Telehealth Services for Monitoring Patients with Asthma, COPD, and Heart Failure

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Contents

List of Figures

List of Tables

Executive Summary

This report presents an evaluation of three families of telehealth services developed by NHS Highland that used Home and Mobile Health Monitoring (HMHM) to support people with asthma, Heart Failure, and Chronic Obstructive Pulmonary Disorder (COPD) in managing their own illness. The NHS Highland Technology Enabled Care (TEC) team developed and deployed the services with funding from the Scottish Government's Technology Enabled Care (TEC) programme. Services were evaluated against eight benchmarks that had been agreed for the TEC programme. Additional aspects not covered by these benchmarks that emerged in the evaluation are also highlighted. The evaluation was contracted for 28 person days, and two intermediate reports have been delivered.

The report builds on seven distinct data sources: the TEC Minimum Data Set, covering demographics and characteristics of the population; data generated by Motiva; data generated by Florence; interviews with clinicians, patients, and carers that were conducted by the evaluator; and three data sets compiled by NHS Highland, data on hospital outpatient and inpatient appointments, GP appointments, and prescriptions.

There is positive evidence for all eight aspects of the HMHM logic model:

There are more HMHM enabled services: The three services analysed here did not exist before the TEC programme, but have now become part of standard practice for Tier 3 and 4 patients with COPD, Heart Failure, and Asthma, who are seeing specialist clinicians.

Patients are more aware of self management: They adhere well to measurement protocols, and telehealth helps them recognise symptoms and better understand their condition.

Increased % of population self-managing: Patients adhere well to symptom monitoring protocols, they know how to initiate appropriate action, and telehealth supports them in making better lifestyle choices.

Increase in condition control: Clinicians report better symptom control for many patients whose control was previously poor, and patients feel more in control. This may not necessarily translate into better scores on symptom questionnaires.

Clinical team response: Clinicians actively use telehealth in their practice, and patients feel that the telehealth service works well in connecting them to appropriate care.

Access to Services: Despite clear infrastructure issues, telehealth is seen as greatly improving access to services in areas that need them.

Hospital Admissions: Although the number of patients is too small for statistically significant conclusions, the evidence so far suggests that telehealth may reduce both the number of admissions and the number of beddays.

Optimised Face to Face Contacts: Telehealth increases the quality of face-to-face consultations with the specialist nurses. There may be a reduction in GP contacts, and preliminary data show no reduction in outpatient appointments.

A reanalysis of the evidence from a realist evaluation perspective suggests that telehealth as implemented here works because telehealth creates an effective link between patients and clinicians despite great distances. This allows patients to feel heard and looked after, and clinicians to get an up to date, accurate picture of their patients' condition, which facilitates better clinical decisions. While telehealth does lead to more and better self-management, it remains to be seen whether the effect can be replicated without a trusted clinician in the loop. Well implemented telehealth also benefits carers, who are often neglected in the design of telehealth solutions, primarily by providing much needed reassurance.

While current Florence-based services work well, those services lack a key ingredient that patients and carers valued with Motiva, namely access to graphs of their own data. Further services should also adopt a more holistic approach, since many chronic illnesses are comorbid. One or two texts and measurements a day for one service do not represent a great burden; five or six for three different services do.

1 Introduction

As part of the evaluation of the Technology Enhanced Care (TEC) Programme across Scotland, NHS Highland commissioned an independent Service Evaluation of three telehealth patient monitoring services, covering Asthma, Chronic Obstructive Pulmonary Disease (COPD), and Heart Failure (HF). The evaluation was contracted for 28 work days (about six work weeks), and in addition to this report, two intermediate reports were produced, (Wolters, 2016) and (Wolters, 2017).

A Realist Evaluation framework (Pawson and Tilley, 1997) was chosen for the evaluation. Realist Evaluation uses all available evidence, both quantiative and qualitative, to elucidate what works for whom under which circumstances. Due to the timescale of the evaluation, and the incidence rate of the three conditions in the Highlands, a solely quantitative evaluation with sufficient power and control over potentially confounding factors was not possible. Realist evaluation also interfaces well with the Contribution Analysis (Mayne, 2008) framework used in the evaluation of the entire TEC programme, as it emphasises what contributes to positive outcomes, and is based on an initial theory, much like the logic model used for Contribution Analysis. While this evaluation does not address cost-effectiveness, some of the data may be useful for cost-effectiveness models.

In this report, I first briefly describe the services to be evaluated and the data sets provided. For further details, I refer to (Wolters, 2016). Next, I outline the initial theory and describe the methods used. Then, I set out key evidence for the outcomes reported in the Year 1 contribution story for the overall evaluation of the TEC programme, structured following the TEC HMHM Evaluation Logic Model (Alexander, 2017). Finally, I reframe the evidence from a Realist Evaluation perspective, and discuss additional findings that go beyond the model. I consider three key stakeholder groups, patients, clinicians, and carers, and outline suggestions for improving services.

2 Services Evaluated

Three services were evaluated:

1. The family of Florence protocols deployed for Asthma self-management, including the Lite protocol
2. The Philips Motiva solution and the Florence protocols for self-management of COPD
3. The Philips Motiva solution and the Florence protocols for self-management of Heart Failure

As soon as each family of services was in place, Tier 3 and 4 patients who were eligible and consented were moved onto them. The provision of Motiva stopped at the end of January 2017, because the contract with Philips ended and it was mutually agreed that it should not be extended. Eligible patients were moved onto replacement Florence protocols, which had been designed during the preceding months, and had In this section, I provide a brief sketch of all three solutions; more detailed information is available in (Wolters, 2016) and in NHS Highland's own protocols.

2.1 Two Approaches: Florence versus Motiva

The Florence protocols are mobile phone based. Florence texts patients with a request for information, and patients reply with a text message. These data are then classified and logged. Depending on the information received, Florence may request further information or provide advice to the patient. All information, both

symptoms such as breathlessness and physiological data, such as peak flow, weight, or blood pressure, are self reported. Patients measure physiological data themselves. If readings fall into a pre-defined critical range, clinicians are alerted. Florence can also send patients reminders and educational text messages.

Motiva is designed around a tablet where patients can complete self-report questionnaires, view their own data, and access educational material, including videos. Some devices for measuring relevant data, such as blood pressure or weight, are part of the Motiva system and automatically transmit their data to the main tablet. Other values, such as blood oxygen saturation, had to be entered by the patient. The tablet requires a working Internet connection, either broadband or 3G, to transmit readings to the main server. Clinicians need to check the Motiva clinician interview themselves to determine whether any of their patients need to be contacted.

While the Motiva system provides data dashboards to both the patient and their carer(s) and the clinician, Florence only provides such a dashboard to the clinician; the patient received pre-programmed feedback.

Both systems are vulnerable to wrong readings. Florence data may be affected by the patient's inability to read values, by values that are (intentionally or unintentionally) mistyped, and by wrong use of the device. Motiva data may be affected by wrong use of the measurement device, by problems with transmission to the tablet, and by people (or, in the case of scales, people and animals) other than the patient using the device.

2.2 Asthma

The standard asthma protocol requires patients to submit a peak flow reading twice a day, once in the morning and once in the evening. This is to capture changes in peak flow patterns. Each person has their individual best peak flow, which is the maximum peak flow that they can achieve when functioning at their best. Since Florence protocols consist of a simple set of if-then rules and do not allow numerical variables, there is a separate protocol for each target maximum peak flow.

From February 2017, a Lite protocol was implemented, which only requires two readings to be submitted per week. The Lite protocol is used for patients who are relatively stable; if their asthma worsens, they may move back to the standard protocol.

2.3 COPD

2.3.1 Motiva

Patients were asked to log their blood oxygen saturation (SpO2), blood pressure, and pulse every day. Additionally, the following information was collected:

1. A daily traffic light survey, where patients state whether they experience any symptoms and provide information about them
2. Baseline and follow-up surveys about the patient's ability to self-manage. Follow-up survey data was collected three months after the baseline data
3. Evaluation surveys for the Motiva system
4. A baseline condition-specific survey, the St George's Respiratory Questionnaire for COPD (Meguro et al., 2007), which covers the severity of symptoms and the impact on the patient's daily life

A survey about the installation was also completed, but these data are less relevant for the present evaluation. An analysis of installation surveys that covers most of the deployed Motiva systems can be found in (Wolters, 2016).

2.3.2 Florence

The main Florence protocol monitors oxygen saturation. Patients are asked to enter their value each day. If values are critical, patients are given advice, if not, follow up questions about relevant symptoms, such as breathlessness and sputum, are asked. Based on their responses, patients are informed whether thet are in the Green, Amber, or Red traffic light zone, following the traffic light system developed by Chest, Heart, and Stroke Scotland. The protocol is described further in Table 5.2.1.

2.4 Heart Failure

2.4.1 Motiva

Patients were asked to measure their weight, blood pressure, and pulse every day. Additionally, the following information was collected:

1. A daily traffic light survey, where patients state whether they experience any symptoms and provide information about them
2. Baseline and exit surveys about the patient's ability to self-manage.
3. Evaluation surveys for the Motiva system
4. A baseline condition-specific survey, the SCHFI (Riegel et al., 2009), which measures patients' self-reported ability to self-manage their condition and to use specific well-validated self-management strategies.
5. Weekly medication change survey

Installation surveys are analysed in (Wolters, 2016).

2.4.2 Florence

The main protocol for Heart Failure, called baseline protocol, focuses on weight. Its structure is similar to the COPD protocol. There is also an extended protocol, which can be deployed if more in-depth monitoring is needed, which also covers oxygen saturation, and there are supplementary protocols for blood pressure and medication. All protocols are summarised in Table 5.2.1. For this evaluation, analysis focused on the main protocol because most patients used it. In the following text, we will refer to it as the baseline protocol, because that is the name under which it occurs in the data set.

3 Data

For all data sets used in this service evaluation, we obtained Caldicott approval. The data sets were provided on the condition that they were fully anonymised, and no data rendering a patient identifiable were retained. All data were anonymised by NHS Highland. For the analysis, all patients were identified by their system ID,

Table 1: Indicators for the Scottish Index of Multiple Deprivation Domains Geographic Access and Health

Domain	Indicators
Health	Standardised Mortality Ratio
	Hospital stays (CIS) related to alcohol misuse
	Hospital stays (CIS) related to drug misuse
	Comparative illness factor
	Emergency stays (CIS) in hospital
	Proportion of population being prescribed drugs for anxiety, depression or psychosis
	Proportion of live singleton births of low birth weight.
Geographic Access	Drive Time
	Public Transport

which can only be mapped onto their CHI number by NHS Highland, who hold these mappings securely. In the following subsections, the data sources are described in more detail.

3.1 Minimum TEC Data Set

Each of the trusts involved in the TEC programme assembled a Minimum Data Set that describes the patients enrolled in the programme. This data set is used here to characterise the population enrolled in the three services. For anonymisation purposes, the patient's name, contact address, CHI number, and the contact information of their GP were removed.

Due to the amount of manual work involved in the anonymisation, the version of the Minimum Data Set discussed here only covers patients that were enrolled by the end of January 2017 (COPD, Heart Failure) or mid February (Asthma).

Given the low population density of the area covered by NHS Highland, any high level post code data could have rendered a patient identifiable. Therefore, information about the geographical area was replaced by information about its position in the Scottish Index of Multiple Deprivation SIMD16 (Scottish Government, 2016). This index combines scores on 36 measures of deprivation that are grouped into seven domains. Geographical areas with a lower score are more deprived than areas with a higher score.

For the purpose of this evaluation, we used the overall SIMD score and the sub-score for two domains, geographic access and health. Health was used as a proxy for the general health of the population in the area, while geographic access indicates how easy it is for a person to access relevant resources. Geographic access involves travel times to GP surgery, post office, and retail centre (this is likely to include pharmacies). The measures (indicators) that are used to calculate the domain scores are outlined in Table 1.

Since SIMD scores are based on cells of around 760 people in a specific location, the exact scores would make patients identifiable. Therefore, they were translated into quintiles. Quintiles divide all SIMD scores into five equal parts. The lowest fifth corresponds to the first quintile, and the highest fifth to the fifth quintile.

Data Table 1 summarises the demographics of the patients in the Minimum Data Set as of February 2017. In each case, telehealth was initiatied through a specialist clinical service pathway, and the key clinical outcomes were the same.

The three conditions have different demographics. Asthma patients are predominantly younger, while COPD and Heart Failure patients are aged 55 and older, and Heart Failure patients tend to be older than COPD

Table 2: Data Table 1: Demographics of the Minimum Data Set

		Asthma	COPD	Heart Failure
Gender	Female	41	26	11
	Male	30	22	47
Age	0-17	1	0	0
	18-44	42	0	0
	45-54	17	0	2
	55-64	9	16	10
	65-74	2	19	23
	75-84	0	10	16
	85+	0	3	7
Tier	Tier 2	4	0	0
	Tier 3	39	47	58
	Tier 4	28	1	0

Table 3: Data Table 2: SIMD Quintiles

Condition		Q1	Q2	Q3	Q4	Q5	No Data
Asthma	N	5	11	23	23	6	3
	%	7	15	32	32	8	4
COPD	N	9	12	12	16	4	1
	%	17	22	22	30	7	2
Heart Failure	N	5	11	23	23	6	3
	%	3	22	36	27	9	3

patients. Asthma patients are somewhat more likely to be female, most Heart Failure patients are male, and the gender distribution for COPD is roughly balanced.

Most of the telehealth patients come from areas of the Highlands that are in the third or fourth quintile of SIMD scores (Data Table 2 and Data Table 3) and SIMD health scores. This means that these areas are less deprived, and have fewer health needs, compared to Scotland as a whole. At first glance, it may seem that COPD patients are somewhat more likely to come from more deprived areas, and from areas that have greater health needs, but this trend is not statistically significant (Kruskal-Wallis test, p=0.7).

3.2 Motiva

For Heart Failure, patients were expected to log their weight, blood pressure, and pulse. For COPD, patients were expected to log their blood oxygen saturation (SpO2), blood pressure, and pulse.

The Motiva data additionally contains the following surveys:

1. Traffic light surveys for each condition, where patients state whether they experience any symptoms and provide information about them
2. Baseline and exit surveys about the patient's ability to self-manage.
3. Evaluation surveys for the Motiva system

Table 4: Data Table 3: SIMD Health Domain Quintiles

Condition		Q1	Q2	Q3	Q4	Q5	No Data
Asthma	N	4	8	21	22	13	3
	%	6	11	30	31	18	4
COPD	N	7	12	9	16	9	1
	%	13	22	17	30	17	2
Heart Failure	N	4	8	21	22	13	3
	%	4	18	25	42	7	3

4. Baseline condition-specific surveys (St George's Respiratory Questionnaire for COPD (Meguro et al., 2007), SCHFI survey for Heart Failure (Riegel et al., 2009))
5. Weekly medication change survey (heart failure only)

This report does not include an analysis of the installation survey and the follow up survey about the installation; results for the time leading up to October 2016 are covered in (Wolters, 2016).

The Motiva data come from a master EXCEL file that was generated by Philips from their complete database, ending with the last participants who were taken off Motiva at the end of January 2017, when provision ended.

3.3 Florence

The Florence data come from three of the reports that can be extracted from the Florence administrator interface, reports R12, R13, and R14. These reports document each text message that was sent by the system (R14), each text message that the system received from the patient (R13), and each reading received (R12). Unfortunately, R13 only notes whether the answer matched a profile, not what the answer was. R12 contains all received readings, with numerical values, a categorisation, and the name of the value type as specified in the protocol.

These reports were filtered to focus only on the deployed, final protocols. Additional PDF reports that document overall uptake of Florence services are also available, but the data was not entered into spreadsheets for use in this report. For the present report, we only consider Florence data collected between February 2016, when the service began, and June 30, 2017.

3.4 Hospital Data

Hospital data were extracted from TRAC using a semiautomated process. For each patient, all inpatient stays and outpatient appointments were listed from January 1, 2015, until the end of June, 2017. For some patients, there was information about discharge time, for others, not. To ensure consistency, the duration of all hospital stays was rounded up to the nearest full day. Bed days were only counted for inpatient stays involving at least one overnight stay. Some patients had data entry errors resulting in hospital stays of 366 days. That was corrected.

For each appointment, the associated specialty was extracted, as well. Outpatient appointments also included information about the date, and about patient attendance; inpatient stays are associated with admission date and discharge date.

3.5 GP Data

GP data was collected using an EXCEL spreadsheet tool developed by Joanna Gilliatt, NHS Highland, and completed by several GP practices who had patients enrolled on Motiva and/or Florence. Practices were asked to provide information about every time the patient was seen regarding the condition for which they were receiving telehealth. The spreadsheet tool collected the following data:

- Where and how the patient was seen. Options included Surgery, Home visit, Phone consultation, Letter, Email, and Other. Some practices also included A&E, the Minor Injuries Unit, or hospital.
- Who saw the patient. Options included GP, Nurse, Nurse practitioner, Healthcare assistant, Nursing assistant, and Other. Some practices also included admin staff, or specified the person who had written the letter (consultant, nurse specialist)
- Whether the record was related to the condition for which the patient was receiving telehealth (COPD, Asthma, Heart Failure)

An appointment was recorded as face to face if it occurred within a primary care setting, and if a home visit or a surgery visit was involved.

Despite having been provided with a tool, the data returned varied greatly between practices and patients. Therefore, all target condition related appointments within primary care, and all primary care face to face consultations, were coded by hand based on the information provided, and relevant information was manually distilled into a master spreadsheet.

3.6 Prescription Data

The prescription data contain all prescriptions of relevant medications and inhalers issued for each of the patients with asthma and COPD. For each prescription, we have the name of the medication, the month the prescription was issued, the formulation (caps, drops, inhaler, injectable, solution, or tablets), the number of items (e.g., individual tablets), and the quantity (e.g., number of packets of tablets).

3.7 Interviews

Interviews with clinicians were conducted at the start of the evaluation (July 2016) and when discussing results from the initial quantitative data analysis as well as initial findings from the patient interviews (January 2017, February 2017, March 2017, June 2017). Interviews with patients took place in February 2017 (COPD / Heart Failure) and Summer 2017 (Asthma). Patients were recruited through the specialist nurses and consented to being contacted by me. All interviews were recorded using interviewer notes. A list of interviews is given in Table 3.7.

4 Analysis Method

4.1 Quantitative Analysis

All percentages are rounded to full percent, given that the number of patients under consideration is never higher than 100. Analyses were conducted using the free statistical software R. Most of the statistics are

Table 5: List of People Interviewed for the Evaluation. C: Clinician, P: Patient. Number: Interview number. a/b: People interviewed together

ID	Condition	Notes	Modality
P1	Heart Failure	male patient	face to face
P2a	Heart Failure	male patient	face to face
P2b		female spouse (carer)	
P3	Heart Failure	male patient	face to face
P4a	Heart Failure	male patient	face to face
P4b		female spouse (carer)	
P5	COPD	female patient	face to face
P6a	Asthma	female patient	Skype
P6b		male spouse (carer)	
P7	Asthma	male patient	email
P8	Asthma	male patient	email
P9	Asthma	female patient	email
CA	Asthma	specialist respiratory nurse	face to face
CH	Heart Failure	specialist heart failure nurse	face to face, phone
CO	COPD	specialist COPD nurse	face to face, phone

descriptive. The following packages were used: tidyverse (Wickham, 2017) for data manipulation and summarisation, coin (Hothorn et al., 2008) for inferential tests, and ggplot (Wickham, 2009) for graphics.

4.2 Qualitative Analysis

The qualitative data analysed consisted of interview notes, research notes, and emails. The qualitative data were analysed using thematic analysis, with an emphasis on themes that were relevant for the evaluation of the systems.

5 Evidence Towards the National HMHM Logic Model

The National HMHM Logic Model used for the Scotland-wide evaluation of the TEC programme is detailed in (Alexander, 2017) and summarised in Figure 5. Here, we focus on outcomes that were agreed to be relevant for the NHS Highland TEC programme.

5.1 More HMHM Enabled Services

Two sources of information were used to assess uptake of HMHM services, the patients reported in the Minimum Data Set, and the patients who were enrolled in Flo after the cut-off date for the Minimum Data Set. For patient statistics, patients who transitioned from Flo onto Motiva are only counted once.

Over 200 patients have been enrolled in Telehealth across all three services in less than two years after the services began to be deployed. Since we do not have historical incidence and prevalence data for the Highlands for Tier 3 and 4 patients with any of the three diseases, it is difficult to judge uptake by numbers alone. However, from clinician interviews, it seems that Telehealth is now part of standard practice.

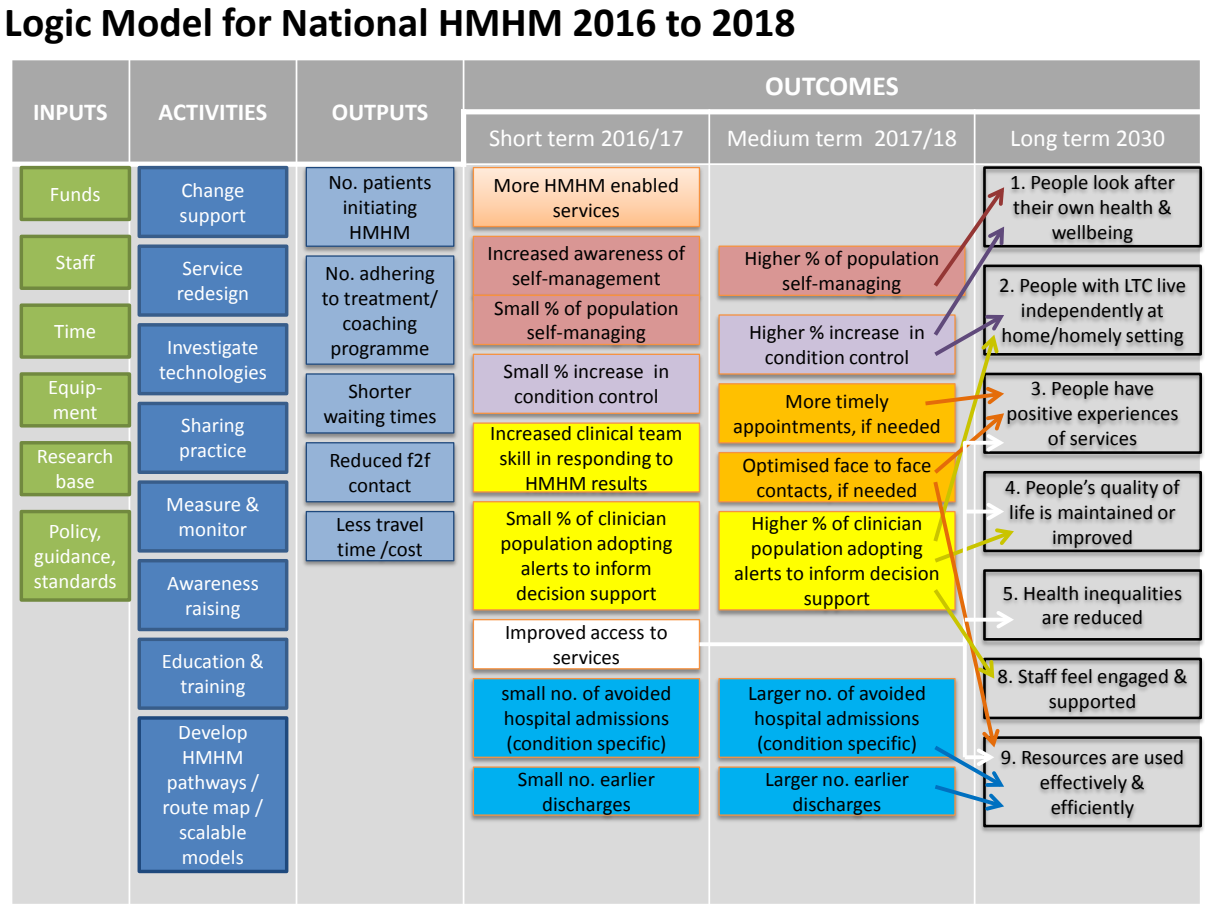

Figure 1: HMHM Logic Model, provided by Helen Alexander, personal communication

Table 6: Data Table 4: Number of Patients Enrolled

	Asthma	COPD	Heart Failure	Overall
Patients until Feb 2017	71	48	58	177
New Feb-June 2017	21	21	4	46
Total Patients	92	69	62	223

Table 7: Data Table 5: Number of Patients Started and Stopped Flo in Minimum Data Set

	Asthma	COPD	Heart Failure	Overall
Switched Protocols before Feb 2017	15	6	9	30
Stopped Motiva before Feb 2017	N/A	44	39	83
Stopped Flo before Feb 2017	9	1	2	12

Data Table 5 shows the number of patients who switched protocols, either between the standard Asthma protocol and Asthma Lite or from Motiva to Florence, the number of Motiva users who were discharged from the telehealth service before Motiva was withdrawn, and the number of patients who were discharged from Florence.

The data represent a snapshot of a time when the Asthma Lite protocol was still relatively new, and when patients had to be transitioned off Motiva quickly, because the service was being withdrawn.

5.1.1 Evidence Summary

The three services analysed here did not exist before the TEC programme, but have now become part of standard practice for Tier 3 and 4 patients with COPD, Heart Failure, and Asthma, who are seeing specialist clinicians. The new suite of Florence protocols, as described above, is tailored to patients' specific needs and, where indicated, reduces the amount and frequency of monitoring required.

5.2 Awareness of Self-Management

5.2.1 Adherence

Adherence to self-management protocols indicates whether people are aware of the need to collect data for self-management, and is a precondition for actual self-management—if patients do not know how well or ill they are, they cannot take any measures to manage the potential exacerbation. Therefore, it is relevant for two of the main evaluation outcomes, awareness of self-management and percent of patients self-managing.

Tables 5.2.1 and 5.2.1 set out the expected number of readings per day together with the value submitted. For the Florence COPD protocol, the Follow Up is either an alert that the patient is in the critical zone, followed by a question whether they have taken their rescue medication, or a brief traffic light survey. This is the same for the Florence Heart Failure protocol, except that the patient is told to contact a health care professional straight away if they are in the critical zone.

For the purpose of this analysis, we will define patients as adherent to one of the two asthma protocols if the average frequency of readings submitted per month is consistent with missing less than 10% of all readings between their start date and their end date, and somewhat adherent if they miss between 10% and 20% of their readings.

Florence readings were not filtered by type of response (Evaluation question, diary, medication), because matching the data sets was not feasible within the time constraints of this study, and because responses other than readings were relatively rare in the entire data set. For example, in the asthma data, readings below 10, which are candidates for responses to evaluation questions, amount to 1.06% of the entire data set.

Table 8: Ideal Adherence Patterns for each of the Florence Protocols

System	Protocol	Reading	Ideal
Florence	Asthma	Peak Flow	2 per day
	Asthma Lite	Peak Flow	2 per week
	Heart Failure Baseline	Weight	1 per day
		Follow Up if needed	0-2 per day
		Total (if fine)	1 per day
	Heart Failure plus SATS	Blood Oxygen	1 per day
		Weight	1 per day
		Follow Up if problem	0-2 per day
		Total	3 per day
	Heart Failure BP	Blood Pressure	1 per day
	Heart Failure Meds	Medication Taken	1 per day
	COPD	Blood Oxygen	1 per day
		Follow Up if needed	1-2 per day
		Total (if fine)	2 per day

Table 9: Ideal Adherence Patterns for Both Motiva Systems

System	Protocol	Reading	Ideal
Motiva	Heart Failure	weight	1 per day
		BP	1 per day
		Pulse	1 per day
		Traffic Light Survey	1 per day
	COPD	Blood Oxygen	1 per day
		BP	1 per day
		Pulse	1 per day
		Traffic Light Survey	1 per day

Table 10: Data Table 6: Adherence to Florence Protocols

Condition	Patients	Avg. Readings / Day		
		Median	Mean	SD
Asthma Full	92	1.8	1.6	0.7
Asthma Lite	14	0.3	0.3	0.2
Heart Failure Baseline	13	1.1	1.1	0.3
COPD	31	2.2	2.1	0.7

Table 11: Data Table 7: Adherence to Motiva Protocols, By Metric

Measure	Avg. Readings / Day		
	Median	Mean	SD
Blood Pressure	1.1	1.1	0.4
Blood Oxygen	0.9	0.9	0.2
Pulse	1	1.1	1.1
Weight	1	0.9	0.4
COPD Traffic Light	0.9	0.8	0.3
HF Traffic Light	0.9	0.7	0.3

Thus, a person who is supposed to submit one reading a week would be classified as adherent if they forget to submit reading every other week, and they would be classified as somewhat adherent if they forget to submit one or two readings every week.

For the full asthma protocol, adherent patients should therefore submit an average of more than 1.8 readings per day, while somewhat adherent patients would submit an average of between 1.8 and 1.6 readings per day. For the Lite asthma protocol, adherent patients are likely to submit around 0.3 readings per day, and somewhat adherent patients around 0.2 readings per day.

The statistics in Data Table 6 show that on average, patients adhere well to the Lite protocol, but are likely to forget a few readings per week on the Full asthma protocol. For the Florence COPD and Heart Failure Baseline protocols, the average number of responses received per day is consistent with a pattern where patients typically do well, and report in regularly, with only a few exacerbations. There were not enough data points for the other Heart Failure protocols to produce meaningful adherence data.

Data Table 7 shows the corresponding findings for Motiva. Patients were reliable when it came to taking their blood pressure, pulse, weight, and blood oxygen saturation measures; blood pressure and pulse measurements in particular were sometimes repeated. Patients were less diligent when it came to the traffic light surveys.

5.2.2 Evaluation Surveys

33 (63%) of all 52 patients enrolled in the Heart Failure version responded to the evaluation survey that was presented after three months. For COPD, 32 (76%) of 42 patients responded. For the purpose of this outcome, we will focus on whether patients felt that telehealth helped them understand their condition, and whether they felt that their ability to recognise signs of decompensations or exacerbations had improved. Results are summarised in Data Table 8.

Almost all patients agreed that telehealth had helped them understand their condition and recognise symptoms.

Table 12: Data Table 8: Self Management Surveys (Motiva)

			COPD			Heart Failure		
			No	A Bit	A Lot	No	A Bit	A Lot
Help Understand Condition	Traffic Light	N	1	14	17	2	11	20
		%	3	44	53	6	33	61
	Readings	N	0	14	18	3	7	23
		%	0	44	56	9	21	70
Help Recognise	Decompensation	N	0	0	0	6	10	17
		%	0	0	0	18	30	52
	Exacerbation	N	2	15	15	0	0	0
		%	6	47	47	0	0	0

Half the COPD patients and most heart failure patients felt that the readings had helped a lot. Half the COPD patients saw a real difference in their ability to recognise exacerbations, and half the heart failure patients felt that telehealth had substantially improved their ability to recognise decompensations.

The results of a five item evaluation questionnaire for Florence are partially logged in the data received as part of the TEC Minimum Data Set. A preliminary analysis can be found in (Wolters, 2016). A full analysis was not possible due to the data management issues outlined above.

5.2.3 Interview Data (Patients)

Several of the patients interviewed based their self-management on an awareness of their own bodies and their own health. While some patients benefited greatly from having a more objective assessment of their health in the form of validated physiological measures, others tended to correlate the quantitative data with their own perception and the effect of their condition on daily life.

Some patients would use the time spent on telehealth to develop and validate shortcuts that did not rely on objective physiological measures. For example, P1 found that if his ankle swelled by a certain amount, then he was likely to need a diuretic. This tendency may be more pronounced for patients who have been living with their condition for a long time.

Patients who had been newly diagnosed with the condition, on the other hand, can use an initial period on telehealth to internalise how measures such as weight and blood pressure can be used to self-manage a condition. For example, P2b purchased scales after they had been discharged from Motiva so that they could keep tracking P2a's weight.

5.2.4 Interview Data (Clinicians)

Clinicians found several positive effects. CO reports that seeing his readings convinced one patient, who had been adamant that he was not ill, that he had indeed COPD. CA moved her "problem patients" onto the Florence Asthma protocol when it first started, and found that they finally started taking regular peak flow readings.

5.2.5 Evidence Summary

Patients adhere to telehealth, which shows awareness of self-management, and actively use the data to gain insight into their condition and take medications, if necessary.

5.3 Percentage of Population Self-Managing

5.3.1 Quantitative Data

5.3.1.1 Evidence from Surveys and Protocols

For Asthma, we report the number of patients who moved from the full protocol, which required peak flow readings twice a day, to the Lite protocol, which requires readings twice a week. Out of all patients that moved onto the Lite protocol, only one needed to be stepped back up. The Lite protocol thus proves to be useful in supporting patients who regularly check their peak flow, and who are relatively stable.

For Heart Failure, a standardised questionnaire, the SCHFI, was administered to gauge the extent to which patients followed best practice in managing their condition. The SCHFI was administered twice, once at the start of Motiva, and once after twelve weeks. On average, the score improved by 4.5 points, which is statistically significant (paired t-test, $t=2.4023$, $df=32$, $p<0.03$).

5.3.1.2 Evidence from Prescription Data

For this analysis, we distinguish between three types of medications, short-acting bronchodilators, long-acting bronchodilators, and steroids. For each medication, the type was established by consulting medicine data bases— this may not reflect how the medication was actually used in treatment. For each class of medication, we compare the following indicators per month before and after the start of telehealth:

- number of prescriptions
- total number of items (for prescriptions that consist of several items)
- number of units (for tablets)

Figures 2 and 3 shows that the number of prescriptions per month increases after a telehealth system has been initiated for Flo, whereas for Motiva, the prescriptions remain relatively constant. This is not because prescribers switch to smaller package sizes for medication that is taken as capsules and tablets. As we can see in Figures 4 and 5, the total number of capsules and tablets issued to patients rises as well.

There are several possible reasons for this. It is possible that patients are prescribed more medication because they are sicker. On the other hand, patients may have finally started taking their prescribed medications as prescribed, including rescue medication. Further complicating factors are that telehealth is often initiated as people are released from hospital after a first diagnosis or an exacerbation, and that medication may be adjusted once telehealth provides a better picture of a patient's condition. All of these factors can lead to an increase in the number of prescriptions.

5.3.2 Interview Data (Patients)

As we have already seen, patients, especially those who are newly diagnosed, get used to good self-management practices through telehealth. It remains to be seen to what extent these practices persist

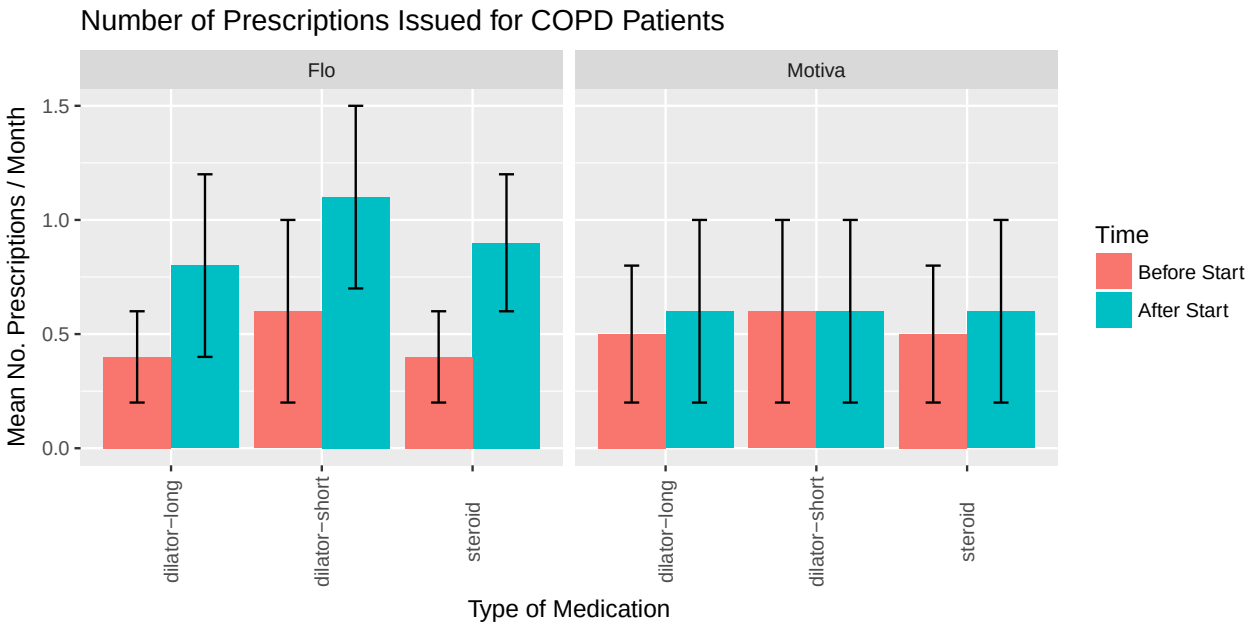

Figure 2: Average number of prescriptions issued per month and per patient before and after starting telehealth for COPD.

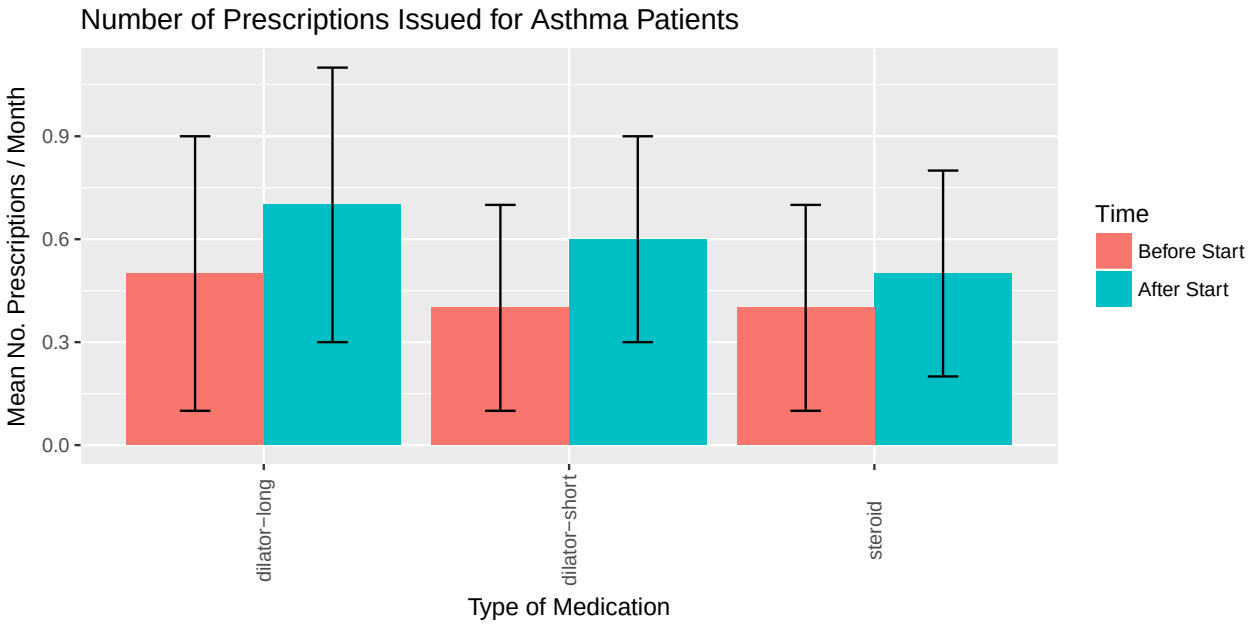

Figure 3: Average number of prescriptions issued per month and per patient before and after starting telehealth for Asthma.

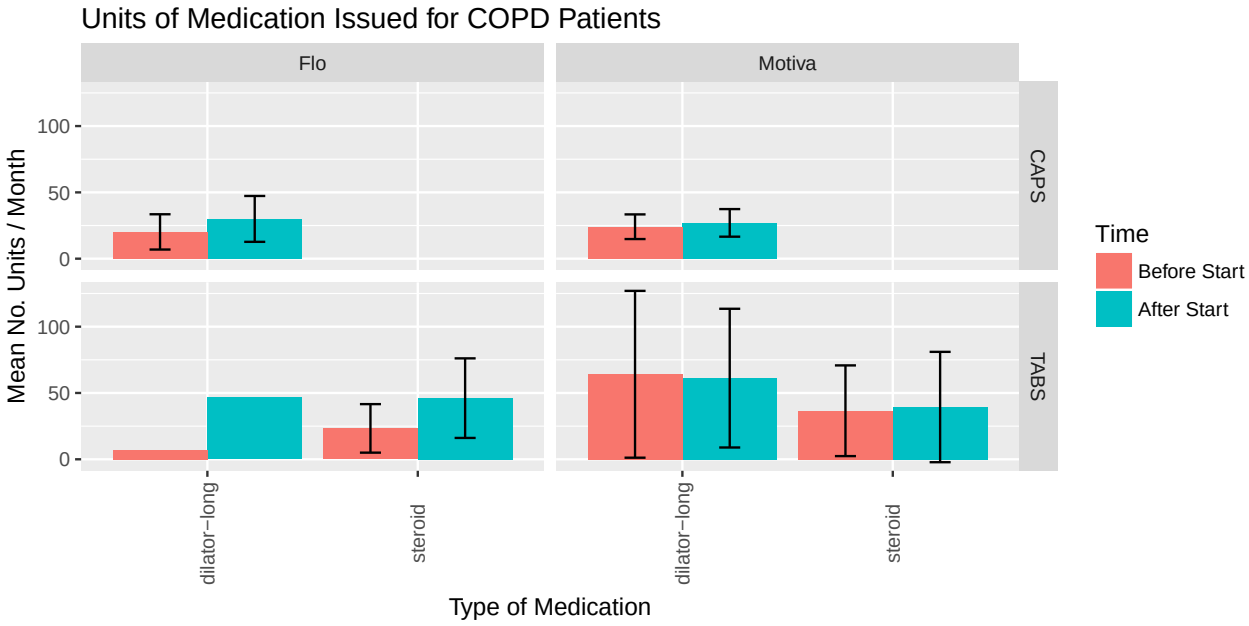

Figure 4: Number of capsules and tablets issued per month and per patient before and after starting telehealth for COPD.

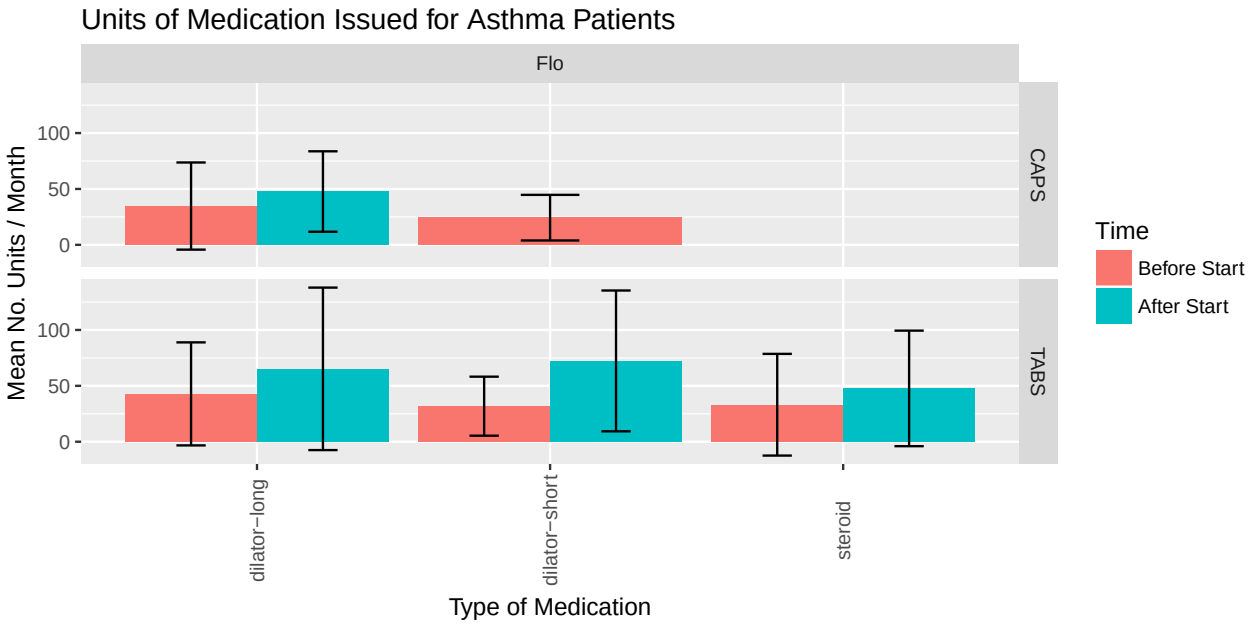

Figure 5: Number of capsules and tablets issued per month and per patient before and after starting telehealth for asthma.

once patients are discharged. However, the asthma patients in particular report being far more consistent in tracking their peak flow, and they value the immediate, actionable feedback Florence provides.

5.3.3 Interview Data (Clinicians)

Clinicians had many stories that illustrated how patients were self-managing. CH reported a patient who had a critical reading, and had already acted on it by taking a diuretic by the time the nurse called—they knew the nurse would call, they knew what to do, and they did it.

5.3.4 Evidence Summary

People who are on telehealth seem to improve their ability to self-manage by taking the correct medications on time and by changing their lifestyle. Given the evidence discussed in the preceding sections, it is plausible that the increase in prescriptions is due to patients actually taking their medication as prescribed. It remains to be seen whether this persists once they have been discharged from telehealth.

5.4 Increase in Condition Control

5.4.1 Quantitative Data

Some of the relevant data have already been discussed above.

In addition, for COPD, the St George's Respiratory Questionnaire as administered using Motiva provides evidence of self-reported symptoms before and after three months on telehealth. A decrease in scores should correspond to an increase in condition control. There are no significant differences pre and post telehealth on both the overall score and any of the subscales (paired t-test, overall score: $p<0.65$; impact subscale: $p<0.99$; activity subscale: $p<0.31$; symptoms subscale: $p<0.97$)

5.4.2 Interview Data (Patients)

Overall, through the act of monitoring, patients feel more in control of the condition, and are more confident that their condition is manageable. P8 reports having much better control of his asthma. P6a feels that her asthma is as unpredictable as ever, but sees telehealth as providing much needed support. Having access to graphs of their own data, such as those provided by Motiva, provides both feedback and reassurance.

All five patients and couples interviewed who had transitioned off Motiva missed having easy access to the graphs of their measures. The graphs was particularly important to the two carers, one of whom felt very anxious about her husband's health, because they provided evidence of how their spouse was doing. P6b, the husband of P6a, had tracked her peak flows against several variables in a spreadsheet for a while, in order to see whether there was anything which might trigger her asthma attacks that could be controlled, but did not find anything. Even though P6a was still taking regular peak flow readings, the couple no longer tracked them.

5.4.3 Interview Data (Clinicians)

Clinicians reported improved condition control, in particular CA, who was very enthusiastic about Telehealth. She noted that patients, in particular her problem patients, appeared to be hospitalised less often, and that they seemed to have better overall control of their condition.

5.4.4 Evidence Summary

While the data from the COPD symptom questionnaire does not suggest an increase in condition control, patient and clinician reports partially contradict this finding. Some asthma patients feel more in control of their condition, and judging by CA's comments, a key measure of condition control should be reduced hospital admissions. If the increase in prescriptions discussed above is due to people taking their medications, including rescue medications, more diligently, then this also points to better condition control.

5.5 Clinical Team Response

5.5.1 Interview Data (Patients)

All patients interviewed are aware that clinicians use telehealth, and that they are responsive to alerts. Using telehealth means that the clinician is "in the loop" and aware of how patients are doing. This holds even when clinicians are on holiday, and notify patients that they will not be looking at the telehealth data for a week or two (CO). To patients, telehealth means that they are connected to their clinicians, regardless of the distance they need to travel in order to attend clinics at Raigmore. Patients see how telehealth affects clinicians' decision making, for example during medication reviews (P2a, Heart Failure), and appreciate being able to see their charts during consultations (P6a, asthma). Patients know that the readings they submit matter, and this could be the reason for the good adherence we have seen.

5.5.2 Interview Data (Clinicians)

Clinicians are understandably wary of shorthands that rely on patients' subjective impressions of their body. Clinical guidelines are often based on measurements and thresholds. Without that information, it is difficult to make treatment decisions. The high adherence discussed earlier means that with telehealth, clinicians are more likely to get the information they need from patients.

High adherence also implies that clinicians have enough data to see patterns in the readings provided, and it is easy to check in on patients without having to contact them in person. In particular, the data make it a lot easier to fine-tune medications, both when patients are first diagnosed, and when the exacerbations occur that are inevitable in both Heart Failure and COPD.

Clinicians also appreciate being alerted when patients cross a critical boundary in their self-reported measures. The telehealth systems are set up to remind patients of the appropriate actions to be taken in these circumstances, and the clinician can follow up as required. While Florence alerts clinicians, Motiva required clinicians to check their dashboard, which was more time consuming.

Table 13: Data Table 9: SIMD Geographic Access Domain Quintiles

Condition		Q1	Q2	Q3	Q4	Q5	No Data
Asthma	N	33	14	5	9	7	3
	Perc	46	20	7	13	10	4
COPD	N	22	12	9	7	3	1
	Perc	41	22	17	13	6	2
Heart Failure	N	33	14	5	9	7	3
	Perc	39	19	12	12	13	3

5.5.3 Evidence Summary

Clinicians respond well and in a timely manner to telehealth data. Patients are very much aware of this. In fact, the theme of connectedness was very strong in the interviews. In particular, older patients in more remote areas seemed to value it greatly.

5.6 Access to Services

5.6.1 Quantitative Data

Data Table 9 shows the SIMD quintiles for geographical access to services. As expected, most patients come from areas that present significant issues (Q1: worst access, Q5: best access, based on an equal partitioning of all areas of Scotland according to geographical access to services). This underscores the great need for telehealth.

5.6.2 Interview Data (Patients)

Patients feel that telehealth brings them closer to clinicians. As P5 wrote in a letter, such a strong link between patient and clinician is particularly important when faced with a complex, highly variable condition, and she wishes something like this had been available when her daughter was diagnosed with epilepsy.

The effectiveness of the remote links, however, depend greatly on the infrastructure. Florence relies on a good mobile signal, which is not available for many of the patients interviewed, while Motiva required a broadband connection that had to be provided by the NHS. P3 uses a service where text messages can be relayed via the Internet, but both P3 and P5 noted that the reliability of the telehealth service had suffered when they switched from Broadband to mobile.

5.6.3 Interview Data (Clinicians)

Clinicians found that telehealth made it a lot easier to check up on patients without having to rely on home visits or trips to GP practices in remote areas. In particular with Florence, relevant data are pushed to the clinicians.

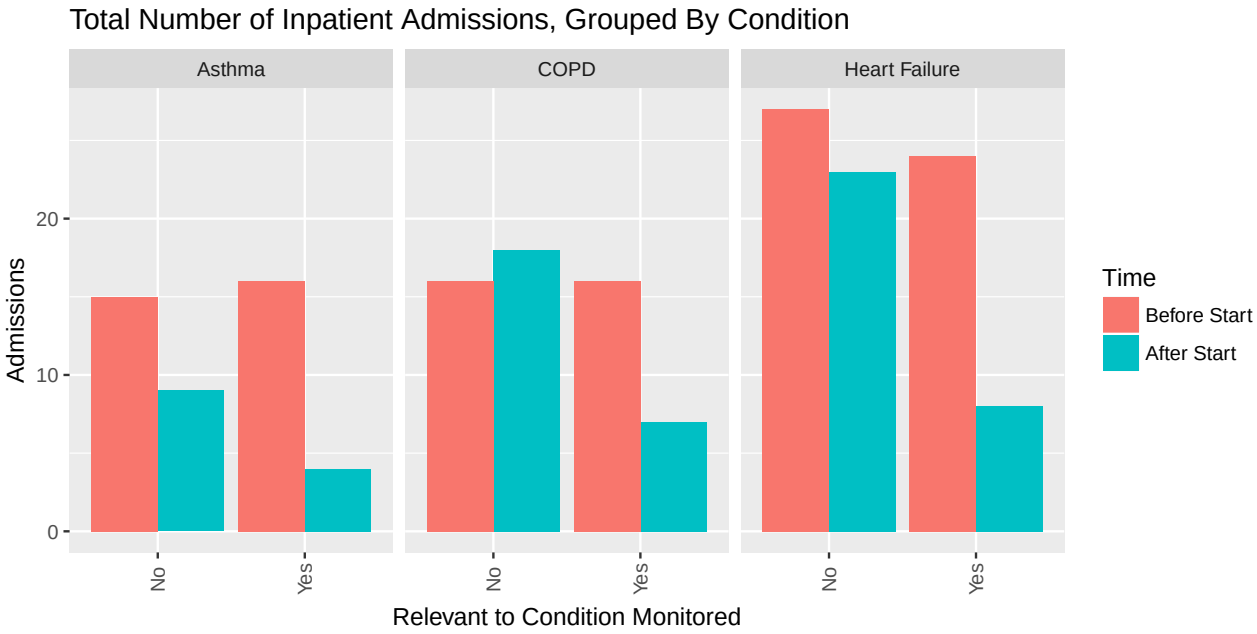

Figure 6: Number of Inpatient Appointments by Condition and Relevance

5.6.4 Evidence Summary

Telehealth clearly increases the perceived accessibility of services, but infrastructure problems need to be addressed.

5.7 Hospital Admissions

Hospital stays required, both for actual condition and for other (overall burden). As proxy for condition, specialty was used.

All inpatient and outpatient appointments that took place between January 1, 2015 and May 31, 2017 (a total period of 29 months) were extracted from the TRAKCare Patient Management system. When analysing the hospital data, we only consider patients who opted in to Telehealth at least 180 days (six months) before the cut-off date, because this allows us to compare hospitalisation rates per half year. This leaves a total of 92 patients, with 29 (32%) on the Asthma protocols, 25 (27%) on COPD, and 38 (41%) with heart failure.

For the purpose of this evaluation, we focus on the total number of admissions and bed days, which is related to the total cost of caring for all patients with the monitored condition within NHS Highland. There are too few patients to create reliable patient-level models of hospitalisation.

Figure 6 shows the number of admissions for all patients before and after initiating telehealth. The Figure shows both admissions involving a specialty that cover the three monitored conditions (*relevant specialties*), asthma, COPD, and Heart Failure, and admissions involving other, unrelated specialties. After patients start telehealth, the number of admissions for relevant specialties decreases substantially more than the number of admissions for other specialties. Figure 6 also illustrates that patients in all three conditions face a significant load of comorbidities.

Table 14: Data Table 10: Total Number of Bed Days

	After Telehealth	Before Telehealth
Asthma	29	129
COPD	186	183
Heart Failure	132	319

Table 15: Data Table 11: Average Number of Bed Days per Half Year

	After Telehealth	Before Telehealth
Asthma	15	52
COPD	110	64
Heart Failure	80	115

Data Table 10 shows the total number of bed days for all patients before and after they started telehealth, while Data Table 11 shows the average number of bed days per half year. The data suggest that bed days were reduced substantially for asthma. We also see a reduction for heart failure, albeit not as pronounced.

There is no difference for COPD, but this is mostly due to one particular patient, who was hospitalised for 106 days for a COPD related condition after the date they started on Motiva. Due to the small number of hospitalisations overall in the data set, it would not be prudent to exclude this patient from analysis as an outlier, as they might be indicative of a group of patients that will experience substantial complications despite their best efforts at adhering to HMHM.

5.7.1 Evidence Summary

Even though it was not possible to create a patient-level model, the reduction in overall bed days and number of admissions for the conditions monitored suggests that telehealth may help avoid hospital admissions. The data only cover patients who initiated telehealth in 2016 and January 2017; an updated data set is needed to establish whether the pattern of reduced hospitalisations and fewer bed days for monitored conditions holds, and whether hospitalisations are still reduced once patients have transitioned off telehealth.

5.8 Optimised Face to Face Contacts

This section considers three types of contacts:

1. Hospital outpatient appointments
2. Face to face consultations at the GP surgery (including home visits)
3. All consultations with health care professionals at the GP surgery or the Primary Care Emergency Centre (face to face, home visits, phone calls)

5.8.1 Quantitative Data

5.8.1.1 Outpatient appointments

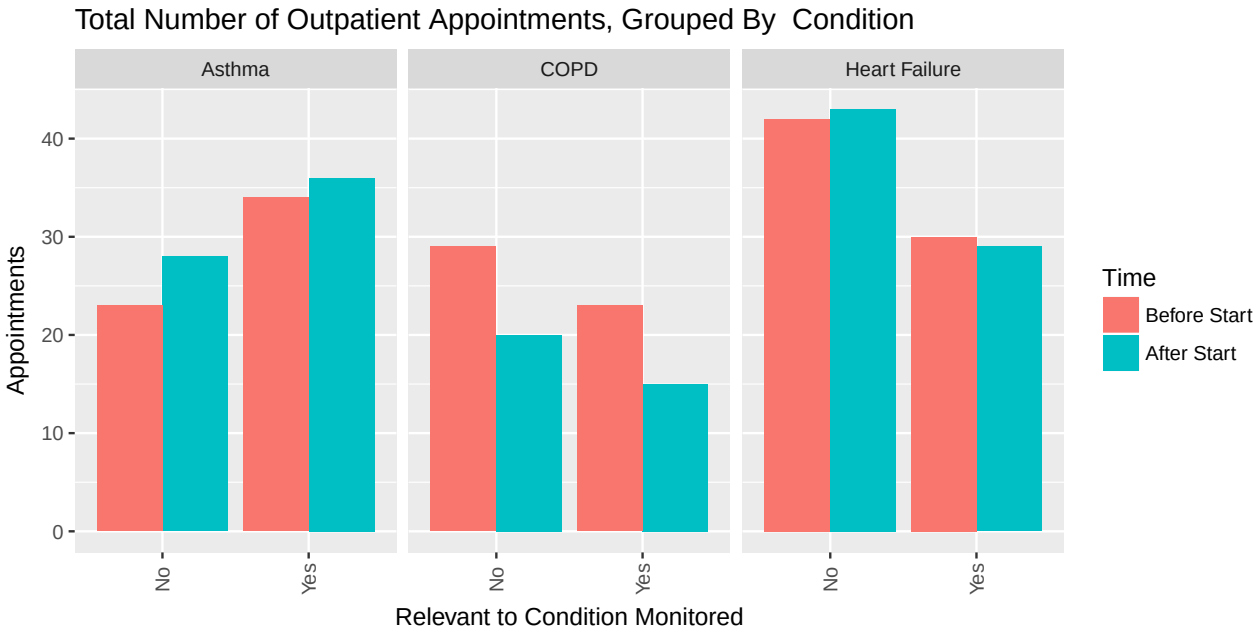

Figure 7: Number of Outpatient Appointments by Condition and Relevance

Again, we only consider patients who opted in to Telehealth at least 180 days (six months) before the cut-off date, because this allows us to compare hospitalisation rates per half year. This leaves a total of 100 patients, with 35 (35%) on the Asthma protocols, 26 (26%) with COPD, and 39 (39%) with heart failure.

Unlike for hospital admissions, we see no reduction in the number of appointments that relate to the condition being monitored. This can have several reasons, such as an overall shift of patient contacts from hospital admissions to outpatient appointments, or a few patients who attend more regularly.

5.8.1.2 GP appointments

We have GP data for 15 patients. Of these, 9 were on the Florence Asthma protocol, and 6 were on the Motiva protocols. While these numbers are not sufficient for statistical comparisons, they are enough to indicate clear trends.

Since the dates on which the GP data was entered varies, it is impossible to establish a definite period for the end of the GP data collection; therefore, we use June 15, 2017, the time by which most of the GP data had been collected, as our end period.

For the Motiva patients, we look at the number of appointments per month before, during, and after the intervention (summarised in Data Table 12); for Florence, all patients for whom we have GP data were still on telehealth, so we only have numbers for before and during telehealth (summarised in Data Table 13).

The patients in this data set represent a variety of situations. Two asthma patients started being seen by their GP for asthma at the same time as being enrolled on Florence. The Heart Failure patient for whom no surgery or phone consultations are recorded was being seen by specialists or at the Device Clinic. As the data show, the frequency of condition related appointments declines while patients use the telehealth service. Most of this decline appears to stem from a reduction in face to face appointments at the surgery. From visual

Table 16: Data Table 12: GP Attendance for Telehealth Related Conditions - Motiva

Condition	All Consultations			Face To Face Only		
	Before	During	After	Before	During	After
COPD	2.1	1	1.4	1.9	0.9	1.3
COPD	0.3	0	0.1	0.2	0	0.1
COPD	2.2	1.2	0.3	1.9	1	0.2
COPD	0.6	0	0.4	0.3	0	0.4
Heart Failure	0.3	0	0.5	0.2	0	0.2
Heart Failure	0	0	0	0	0	0

Table 17: Data Table 13: GP Attendance for Telehealth Related Conditions - Florence

Condition	All Consultations		Face To Face Only	
	Before	During	Before	During
Asthma	0.6	0.1	0.4	0.1
Asthma	0.9	0.3	0.9	0.3
Asthma	0.1	0.1	0	0.1
Asthma	0	0.2	0	0.2
Asthma	0.7	0.2	0.6	0.1
Asthma	0.6	0.5	0.2	0.2
Asthma	0.7	0.2	0.6	0.1
Asthma	2.4	0	1	0
Asthma	0	0	0	0

inspection of the raw data, it appears that after initiation of Telehealth, many of the relevant interactions are letters from the specialist appraising the GP team of changes.

5.8.2 Interview Data

The relevant data have already been discussed above, in the section on Clinical Team Response. Patients know that their specialist nurse clinicians see their telehealth data, and clinicians have an overview of key indicators of their patient's condition at their fingertips. Patients and clinicians feel that better decisions can be made during an outpatient appointment, and that the rationale for these decisions is a lot clearer than before.

5.8.3 Evidence Summary

While the number of outpatient appointments may well increase, the appointments themselves are regarded as better and more efficient. However, a patient-level model is needed to determine whether this increase in appointments is a temporary spike due to the first phase of telehealth initiation, or whether it will even out as clinicians refine their telehealth workflows. The reduction in GP appointments suggests that care for the condition shifts from the GP to the specialist service, at least while patients still need to be on telehealth.

6 What Works for Whom under What Circumstances

In this section, I will summarise my findings from the point of view of Realist Evaluation, which focuses on what services work for which people under what circumstances. In this summary, I will also include some aspects of the three NHS Highland telehealth services that have not been discussed in this document so far, because they are not covered by the logic model of the overall evaluation.

6.1 Patients

It is clear that patients accept telehealth. The key statistic here is adherence—as we have seen, patients use the system regularly. However, it is also useful to know whether patients liked the system they were using. NHS Highland is now regularly gathering user satisfaction data; here, we report two data sets, one data set that summarises patient reaction to Motiva (the exit survey data mentioned earlier), and one data set that was collected for the Asthma service specifically for this evaluation.

Six Florence patients who had agreed to be contacted for this evaluation returned a survey where they rated the Flo using an 11 point instrument based on the System Usability Scale (Barry, 1996), a standard metric for evaluating how users subjectively rate a system. The version we developed yielded ratings between 0 and 24 (higher=better). The average rating was 22.5 (range: 20–24).

We have evaluation data from 65 Motiva patients. 63 (97%) would recommend telehealth to others, and only 2 (3%) would not. 53 (82%) patients found their Motiva system easy to use, including those who would not recommend telehealth to others, while 12 (18%) patients stated that they had a more mixed experience.

Patients were so positive about telehealth because they felt supported and connected to their clinicians. Patients knew that their trusted clinicians had access to a continuous stream of data about their condition, and that clinicians would act on these data. As CO observed, patients did not mind if the clinician who was involved in the telehealth programme was on leave. What mattered was the existence of a reliable connection.

This was particularly clear in the interview data from P2a, P2b, and P5. P5's experience of telehealth has led her to push for better accessibility of telehealth in the remote area where she lives. P2a, who had been newly diagnosed with heart failure, and P2b, his spouse, clearly trusted their clinician. They saw her as somebody who could give them guidance in the uncertain waters of the new diagnosis, which came on top of other long-term illneses, and saw how she used telehealth to adjust medication. This is in line with the findings of other telehealth studies, such as (Fairbrother et al., 2013, 2014), qualitative studies that were conducted in conjunction with large Scottish trials of telehealth.

When asked whether they had ever tracked their symptoms using an app, or had thought about it, only one person, P4, said he did. This suggests that patients may not be interested in tracking without a health care professional in the loop who can help them interpret readings and who integrates the tracked data into the patient's overall care. When the clinician leaves the loop, because they have been discharged, there is a tendency to rely on watching the signs of one's own body instead. Only a few people, such as P2a and P2b, kept up the tracking habit after discharge.

It was also important for patients to be able to see their data. CH reports that one patient was very disconcerted after he had been moved onto Motiva, because he no longer had the graph that showed him how he was doing. This was echoed by all of the interviewees with Motiva experience, in particular the carers.

An aspect that none of the telehealth services addressed was the significant comorbidities in all three patient cohorts. As Figures 6 and 7 show, many patients had a string of inpatient and outpatient appointments that

were not at all related to the condition for which they were being monitored. Due to the relatively small number of patients involved, tabulating comorbidities by condition would make them identifiable. Inpatient specialities were mostly not well defined; frequent outpatient specialties were podiatry, physiotherapy, psychiatry, opthalmology, and orthopaedics.

All of the older patients interviewed had at least one of the chronic illnesses associated with age, typically diabetes, and had already made lifestyle and diet adjustments for this. This means that we need to assess the burden of treatment (May et al, 2014; Ridgeway et al., 2014) more carefully that is associated with telehealth. Some patients did not find Motiva easy to use, but they persevered because they saw the benefit. However, if telehealth systems were implemented for each of these conditions separately, the burden might become unacceptable very soon.

Patients also value their quality of life. If a patient is older, and has made peace with the fact that their chronic condition will have shortened their life, they may not restrict their diet as much as recommended. If a patient with COPD has always smoked, and has many other illnesses in addition to their COPD, they may not have the mental and emotional resources to cope with nicotine withdrawal on top of everything else.

6.2 Clinicians

As we switch perspectives, we also change how we define what works. From the point of view of the healthcare system, cost and resources are important, whereas the patient may focus on quality of care, and a connection to clinicians they trust.

Clinicians are a scarce and costly resource. One of the main barriers to clinicians' acceptance of telehealth is the additional workload it may impose (Sharma et al., 2014; Wade et al., 2016). For the services discussed here, clinicians were well aware of their ever increasing workloads, and saw telehealth as a potential way forward to manage this. Despite their enthusiasm.

Another strong motivation was that telehealth allowed clinicians to improve their care. In the first interview, CA mentioned that she first used the Florence asthma protocol for patients that she was very worried about, who did not control their asthma well, and who were finally tracking their peak flow regularly. CH greatly valued that Motiva avoided data entry errors by sending data from the relevant medical devices straight to the tablet. Having actual hard data at their fingertips for decision making was also seen as an advantage, and clinicians came to trust the data they saw on their dashboards.

A final, important aspect was that the telehealth protocols were designed in close collaboration with the clinicians who would be using them, and the Florence logs show several iterations of deployed and tested protocols. This iterative co-design allowed clinicians to take greater ownership of the service, and ensured that the resulting protocols were better adapted to clinical needs.

Thus, telehealth works for clinicians if it allows them to provice the same or a better standard of care more efficiently, which is necessary if telehealth is to be scalable. While Motiva had more features that patients valued, it was far more difficult for clinicians to see efficiency gains. Motiva required clinicians to check their dashboards regularly, because alerts were only issued within the system, and not pushed to clinicians' phones. The actual implementation of Motiva was also beset with problems; quite a few times, the local handyperson services had to be alerted to fix problems with Internet connectivity. Although Florence also suffers from an infrastructure problem, lack of mobile signal in the Highlands, this is not a problem that clinicians can fix by alerting specialist services; rather, it's a political issue that affects all aspects of life in the Highlands.

When comparing the interviews in Summer 2016 with those in 2017, it becomes apparent that clinicians have

evolved their own efficient workflows, which is much easier for them with Florence. The Asthma protocol now scales much better, especially after introduction of the Lite protocol, and clinicians don't spend as much time checking dashboards.

6.3 Carers

A group of stakeholders that are commonly overlooked are carers. Even though the data are limited to the three carers who were interviewed together with their spouses, and to P5, who was a carer for her daughter, it is difficult to overemphasise just how much carers benefit from telehealth, especially systems like Motiva, that show patients graphs of their data. It allows carers to see how the loved one for whom they are caring is doing. Seeing the data, and knowing that the clinician is in the loop, can be a great relief, especially when carers are struggling with depression and anxiety related to the patient's complex health needs. P5 emphasised repeatedly how much difference a telehealth system that gives patients and carers access to their own data would have made to her own situation, when her daughter was diagnosed with epilepsy. Carers may also add their own data collection efforts, like P6b, who extensively charted his spouse's peak flows and a host of other variables for a couple of weeks to determine what caused exacerbations of her asthma.

From the point of view of carers, a system like Florence is a baseline; it provides much needed reassurance through its link with clinicians. However, what carers would really benefit from is access to data.

7 Conclusion

In this piece of work, I have evaluated three telehealth services provided by NHS Highland, for asthma, COPD, and Heart Failure, both following to the logic model used in the main TEC programme evaluation, and using a Realist Evaluation framework. Findings for asthma and COPD mirror the summary of the evidence in (Morrison et al., 2016): COPD telehealth empowers patients, and is likely to provide clinical benefits for patients with severe asthma, the main target group of the asthma telehealth protocols. Since work on the evaluation was contractually limited to less than six work weeks, many aspects of the systems and their use could not be explored. Cost effectiveness also needs to be explored separately; the main TEC evaluation provides tools for doing this.

Both in terms of the realist evaluation, and in terms of the overall logic model, there is clear evidence that the services as implemented at the moment work. All three services link clinicans and patients in a relatively efficient manner, are used regularly, and play a clear role in clinical decision making.

While the evidence on hospital use and condition control is encouraging, in order to reach firm conclusions, we would require at the very least more in-depth information about each patient, such as when they were diagnosed with the condition they were being monitored for, when they moved to the NHS Highland area, when their prescriptions were changed, and by whom. We also have too few data points for determining which patients are outliers. Given the small size of the population covered by NHS Highland, we would need several years of data before we can distinguish between typical and atypical patterns of hospitalisation with confidence. Finally, we also lack data about GP appointments for most patients.

The gold standard for evaluating whether an intervention is effective for a given quantitative measure is, with good reason, the randomised controlled trial. While it was not possible to set up such a design here, it may be useful to compare data collected across TEC sites.

Going forward, NHS Highland may wish to implement automated reporting that tracks key indicators, such as number of beddays, hospital, and outpatient appointments by condition. The model of co-designing services with clinicians that has been implemented seems to work well; it might be useful to involve patients and carers in service design or revision, especially as the service is extended to conditions that are often comorbid in older people. Otherwise, there is a risk of increasing the burden of telehealth monitoring to a level that is not sustainable for patients.

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