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Hywel Dda University Health Board

Evaluation report:
A real-world evaluation of technology enabled care (TEC) for the remote monitoring of heart failure patients in West Wales.

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Who We Are

In 2021 the Tritech Institute was launched. We are a team based in a bespoke facility within Hywel Dda University Health Board comprising of industry-leading engineers, scientists and clinicians.

Our Institute

Here at TriTech Institute, we support the development of healthcare solutions on a local, national, and global level offering designers and manufacturers a single point of access to the NHS through a collaborative and agile approach.

What We Offer

The team's advanced skills in clinical and research design are combined with technical engineering expertise to manage the whole innovative pathway from early unmet need, through to concept design, prototyping, clinical investigations, and real-world service evaluations.

Our Services

We provide specific services and solutions for clinical engineering, research and innovation and value-based healthcare and can also support with grant writing and submission.

Executive summary

Background

Heart failure (HF) is a syndrome caused by impaired function of the heart to pump blood, and results in substantial morbidity and poor survival rates (von Lueder & Agewall, 2018). HF is the primary diagnosis for more than 100,000 hospital admissions per year in the UK and is a leading cause of morbidity and mortality (BHF, 2020). Despite advancements in medicine, management of HF has been a challenge to health care providers, due to high rates of readmissions (Inamdar & Inamdar, 2016).

Technology enabled care (TEC) is a collective term used to describe emerging technologies and methods such as telehealth, telemedicine, digital and electronic health services. TEC is increasingly viewed as a potential solution to challenges facing modern healthcare such as increasing proportions of elderly persons with chronic diseases (Leonardsen et al., 2020). This report presents the findings of a real-world evaluation of a TEC service for the remote monitoring of HF in Hywel Dda University Health Board (HDUHB), aimed at improving HF management.

Evaluation overview

The TriTech Institute was commissioned by Hywel Dda University Health Board (HDUHB) to evaluate the impact of the TEC programme for HF patients across the three counties of the health board. The TEC HF service was setup in collaboration with the company 'Delta Wellbeing' who conducted end user training and responded to device alerts.

The aim of this real-world evaluation was to understand the impact and any emerging benefits to patients, staff, and the health board for TEC use with heart failure patients at HDUHB. This report covers the evaluation period between June 2021 and October 2022.

Methodology

We collected and analysed data across 5 themes:

1. **TEC recruitment and engagement –** The TEC platform stores data on active and pending patients numbers, and the results of physiological measurements. This data was explored to understand the level of patient recruitment and engagement.

2. **Heart failure informatics –** Data relating to HF related hospital admissions and outpatient appointments investigated any potential effect of TEC use on health care utilisation and clinical outcomes.

3. **Patient Reported Outcome Measures (PROMS) –** PROMS were collected by the value-based healthcare (VBHC) team. This data was analysed to investigate differences in responses between HF patients who used TEC and those who did not, in addition to understanding any relationships between TEC use and PROM responses.

4. **Patient feedback –** Patient feedback was obtained through the platform by a questionnaire, specifically on their attitudes towards TEC use.

5. **Staff feedback –** Staff were consulted during the evaluation period to understand any barriers or facilitators to TEC use with HF patients.

During the evaluation period, 232 HF patients were enrolled onto TEC in HDUHB. The TEC platform tracked patient recruitment and discharge statistics, as well as the patient TEC usage (% response rate to physiological reading requests). The time taken between patient referral and successful set up of patients was also tracked.

Health board informatics recorded HF related hospital admissions and HF outpatient appointments for all patients (TEC and non-TEC) in addition to recorded deaths. Correlation calculations were used to look for any associations between TEC recruitment and compliancy, outpatient appointments and hospital admissions over time. TEC only

informatics data was also filtered for patients who used the TEC service for a period of at least 6 months for a before/after analysis. Multiregression analysis was also undertaken on these factors to analyse potential predictors for patient compliance with the technology.

Staff feedback was obtained during multi-disciplinary team meetings (MDT) and interviews and 27% of patients responded to a feedback survey during September 2022.

Findings

Infrastructure
When considering patients who had used the TEC service for a period of 6 months and comparing against the previous 6 months; there was no overall difference in outpatient appointment rates (P>0.05), but there was a significant reduction in hospital admissions (P<0.05). Patients using TEC were 2.1 (p<0.001) times more likely than those not using TEC to have a virtual outpatient appointment, meaning less travel for patients and less need for clinic space for these appointments.

Data from all counties in HDUHB for heart failure show an inverse relationship between outpatient appointments and hospital admissions. Where more patients were seen in outpatient appointments, HF related hospital admissions decreased. During the evaluation period this was most evident during June and July 2022 where hospital admissions dropped, and outpatient appointments dramatically increased. This coincided with an increase in staffing resources in HF at this time, an important confounder but part of real-world evaluations. The number of TEC related outpatient appointments also correlated with the rate of hospital admissions (r = -0.79, P<0.01), indicating that overall clinic and nursing staff availability is an important confounder.

Patients
Patient responses to the feedback questionnaire were generally positive. Patients reported they received adequate training in using the TEC devices. Patients also reported they believed the TEC equipment was accurate and would help with their care.

The patients who responded to the feedback questionnaire were mainly being contacted by Delta either once a month or less than once a month. Only one from 42 patients reported that they needed help from family members to use the telehealth devices. In general, compliancy rate (usage) of TEC increased between week 1 and 4 as the patients became accustomed to the technology and there was a strong association between compliancy and staffing numbers.

Staff
The nurses working with HF patients had some doubts about the service at first, but they thought they did their best to make it functional. The clinical teams said they did not feel consulted before the service was rolled out. There were some genuine concerns from the HF nurses about the clinical responsibilities and governance surrounding patients using TEC. The clinical staff would appreciate a standard operating procedure (SOP) for using TEC in HF, to clarify the roles and tasks when dealing with alerts and severity of readings.

There was a lack of (or breakdown in) communication between staff from the health board and Delta Wellbeing during various stages of the evaluation. Based on the responses from both of these teams, these communication problems were caused by both technology issues and a lack of clarity from both sides about what the other could view on the system or how they were dealing with patient alerts. This resulted in HF nurses not knowing when patients had been added onto the system and Delta Wellbeing having difficulty with installations. Towards the later stages of the evaluation period, all parties involved began taking steps to improve the process so that the service would run more smoothly. These actions included new documentation for patients and staff, more call centre staff and training from Delta Wellbeing, and additional referral information from the HF nurses to help with device installations.

NB Clearer lines of communication and responsibility as well as adequate staffing must be considered in any future TEC service.

Technology
There were concerns from the HF nurses around the accuracy of the peripheral devices in the TEC system, in particular staff were concerned about the accuracy of the pulse oximeters provided. As a result of the evaluation conversations, some nurses started to compare these oximeters with their manual heart failure assessments in clinic to generate data that would show how the pulse oximeters are not able to identify atrial fibrillation (AF) and may have different heart rate readings than the manual methods in clinic.

HF nurses also felt that electrocardiograph (ECG) monitors would be required as part of the TEC equipment issued to patients, as AF was impossible to detect using the pulse oximeters and was deemed important for this group of patients. Many of the HF nurses reported login issues with the TEC platform. The two-factor identification process was seen as too time consuming in some cases, and nurses often only had a short window in which to use the system. Being automatically logged out after 15 minutes if the nurses stepped away for more urgent tasks were also reported as a major frustration.

Conclusion

There is potential for continued TEC use in HF, to benefit our patients and our health system. The primary clinical benefit identified in this evaluation was the potential of the TEC system to reduce hospital admissions. Reduction in hospital admissions could represent a significant resource saving. An economic assessment would be required to quantify if this resource saving is cost effective against the expense of onboarding, deploying and monitoring. Patient feedback was positive, but staff feedback was less so.

The development of an SOP for TEC use in HF, including advice for patient selection would also be helpful for the HF nurses and third-party organisations such as Delta Wellbeing.

Key recommendations

Recommendation 1:
Economic evaluation

An economic analysis should be conducted on the available data collected from this evaluation, using supplemental data relating to device, software and third party costs to quantify if these were offset by any cost-savings within the health board.

Recommendation 2:
Standardisation of service, SOP development

A detailed SOP is necessary to give confidence and clearer guidance to the clinical staff. This SOP would enable faster recruitment and more engagement, by providing more guidance. Consultation with the HF nurses will help with clinical buy-in and SOP development. As part of this SOP development, the physiological parameters, settings and ideal number of reading requests per week need to be agreed by clinical staff.

Recommendation 3:
Further exploration of hospital avoidance factors

The HF nurses have suggested the need for a bigger data set to examine clinical information such as medication doses and titration rates that could be related to higher admissions.

Recommendation 4:
Continued evaluation phases

The HF TEC service continues post evaluation data collection and any follow on evaluation of the clinical activity after this time would provide further insights into the effectiveness of the technology after the One-Stop HF clinics were started. This subsequent follow on assessment phase could reveal how useful the technology was for adjusting medication doses, which is tracked as part of these one stop clinics.

Recommendation 5:
In-depth analysis of TEC vs non-TEC patient outcomes

We recommend PROMS being captured as a baseline, and then at, specific time points from people receiving TEC versus standard care. This will allow comparisons to be drawn in order to provide a better picture of patient experience as well as allowing for natural progression of disease and the confounders/impacts of other service changes.

Table of Contents

Abbreviations

AF	Atrial fibrillation
BP	Blood pressure
CI	Confidence Interval
COPD	Chronic obstructive pulmonary disease
ECG	Electrocardiogram
EQ-5D-5L	EuroQol, 5 question, 5 domain, 5 measure
HDUHB	Hywel Dda University Health Board
HF	Heart failure
KCCQ-12	Kansas City Cardiomyopathy Questionnaire, short form
MCID	Minimum clinically important difference
MDT	Multidisciplinary team (meetings)
MS	Microsoft
NHS	National Health Service
OP	Outpatient
PHQ-2	Patient health questionnaire (2 question)
PROMS	Patient reported outcome measures
PROMIS	Patient-Reported Outcomes Measurement Information System
QoL	Quality of life
RCT	Randomised controlled trials
TEC	Technology enabled care
VBHC	Value-based health care
VO2	Volume of oxygen
WPAI	Work productivity and activity impairment

Acknowledgements

1. Background

1.1 Heart failure

The syndrome of heart failure (HF) constitutes a major global health care crisis, where patients exhibit substantial morbidity and poor survival rates. HF causes enormous healthcare expenditure and recent reports suggest that the overall number of people living with heart failure is increasing. A sizable portion of HF cases result from long-standing, often inadequately managed hypertension, or ischemic heart disease; major cardiovascular diseases which can evolve from an unhealthy lifestyle. Unhealthy lifestyles are modifiable risk factors and therefore present an opportunity for intervention (von Lueder & Agewall, 2018).

HF can cause problems with the structure of the heart or how it functions and may be caused by conditions such as coronary heart disease, heart valve disease or high blood pressure. Many patients with heart failure have had a heart attack in the past. Heart failure becomes more common in older populations, and has symptoms such as difficulty in breathing, sudden breathlessness in the night, swelling of feet, ankles or abdomen, extreme fatigue or feeling lightheaded and faint (Bupa, 2021).

Despite advancements in medicine, management of HF, which usually presents as a disease syndrome, has been a challenge for health care providers. This difficulty is reflected by relatively high rates of readmissions along with increased mortality and morbidity associated with HF. The clinical syndrome of HF is caused by structural and functional defects in myocardium resulting in impairment of ventricular filling or the ejection of blood. The most common cause for HF is reduced left ventricular myocardial function. However, dysfunction of the pericardium, myocardium, endocardium, heart valves or great vessels alone or in combination is also associated with HF (Inamdar & Inamdar, 2016).

In HF patients, exercise intolerance characterised by the reduction in peak volume of oxygen (VO2)/VO2 max capacity has been considered as the primary predictor of mortality and morbidity. Other predictors are higher age, increased blood urea nitrogen, lower systolic blood pressure, presence of dyspnea at rest, and lack of long-term treatment with a β-blocker, which have all been identified as independent predictors of mortality (Inamdar & Inamdar, 2016).

Heart failure is a major economic problem worldwide with an estimated 1-2% of all healthcare budgets spent on heart failure. The prevalence of heart failure has increased over the past decade, and it is expected that it will further increase due to higher proportions of elderly individuals in western societies. It has been estimated that 0.4−2.2% of the population in industrialized countries suffer from HF, with between 500,000−600,000 incident cases diagnosed each year. HF predominantly affects the elderly, with 80% of HF-related hospitalizations and 90% of HF-related deaths occurring among patients aged 65 years or older (Lesyuk et al., 2018).

Recent estimates suggest that there are 26 million people worldwide with heart failure and more than half a million people living with this syndrome in the United Kingdom alone. Of the 1-2% of the NHS budget that is spent on heart failure, between 60-70% is related to the costs of hospitalisation (Cowie, 2017).

1.2 Remote monitoring of chronic conditions

Technology enabled care (TEC) is a collective term used to describe emerging technologies and methods such as telehealth, telemedicine, digital and electronic health services. TEC is increasingly viewed as a potential solution to the challenges facing modern healthcare such as increasing proportions of elderly persons with chronic diseases (Leonardsen et al., 2020).

As new digital tools and applications are being created and used to manage medical conditions such as heart failure, it is important that the effectiveness and safety of these telemonitoring tools in diagnosing, treating, and managing heart failure is evaluated and compared to traditional face-to-face doctor to patient interaction. When

compared to multidisciplinary intervention programs which are frequently hindered by economic, geographic, and bureaucratic barriers, non-invasive remote monitoring could be a solution to support and promote the care of patients over time. Therefore, it is crucial to identify the most relevant biological parameters to monitor, which heart failure sub-populations may gain real benefits from telehealth interventions and in which specific healthcare subsets these interventions should be implemented in order to maximise value (Gensini et al., 2017).

2. Situation

2.1 Service background and context

Hywel Dda University Health Board (HDUHB) is one of seven local Health Boards in Wales. It provides primary and secondary care services for residents within its borders in the counties of Carmarthenshire, Pembrokeshire, and Ceredigion. HDUHB's population is semi-rural and is served by four main hospitals (Prince Philip, Glangwili, Withybush and Bronglias). HDUHB produced a business case (published February 2021), outlining a 'digital response' to support increased capabilities for patient care. This business case was in support of pro-active care for patients using home monitoring and to support increased independence for patients by providing a means for monitoring their own health (HDUHB, 2021).

The first cohorts of patients for TEC in HDUHB were to benefit from remote patient monitoring using technologies that enable monitoring of vital signs whilst in the home which were linked to a comprehensive monitoring and response pathway. Heart failure (HF) and chronic obstructive pulmonary disease (COPD) patients were included in the first cohort of patients. Deliverables such as benefits in productivity, patient self-management and reduction in likely visits to primary care, or more acute unscheduled episodes in A&E attendances and admissions were anticipated as part of the business case (HDUHB, 2021).

The TEC platform is a web-based application which enables clinicians to monitor and interpret physiological readings recorded by patients in the home using issued devices. Patients were requested to upload their readings to the TEC platform through the Mobile application, which connected to the peripheral devices via Bluetooth, allowing automatic data transfer from the peripheral devices to the monitoring teams. Physiological readings recorded in the TEC platform were assigned a severity level based on parameters set by clinicians. For example a lower severity reading may have indicated a patient's heart rate reaching an upper acceptable limit, whereas a severe reading could indicate the heart rate has exceeded that limit.

Delta Wellbeing (https://deltawellbeing.org.uk/), a TEC company based in Carmarthenshire, operate Delta CONNECT, which is an enhanced lifeline and telecare service funded by Welsh Government's Health and Social Care Regional Integration Fund (RIF), through the West Wales Regional Partnership Board. This service involves staff who support from call centres and who operate in the community. Delta were collaborators of the TEC programme and provided support to HF patients by installing TEC devices, conducted training with patients on use of the devices and responded to lower severity readings on the TEC platform which did not require clinical support.

2.2 Heart Failure patient recruitment

HF patients were recruited from all three counties in HDUHB, with HF specialist nurses identifying suitable persons from their outpatient clinics. All HF patients who were enrolled on to the TEC programme were issued with a pulse oximeter, weighing scale and a blood pressure (BP) monitor in addition to a smart device that could run the Mobile application.
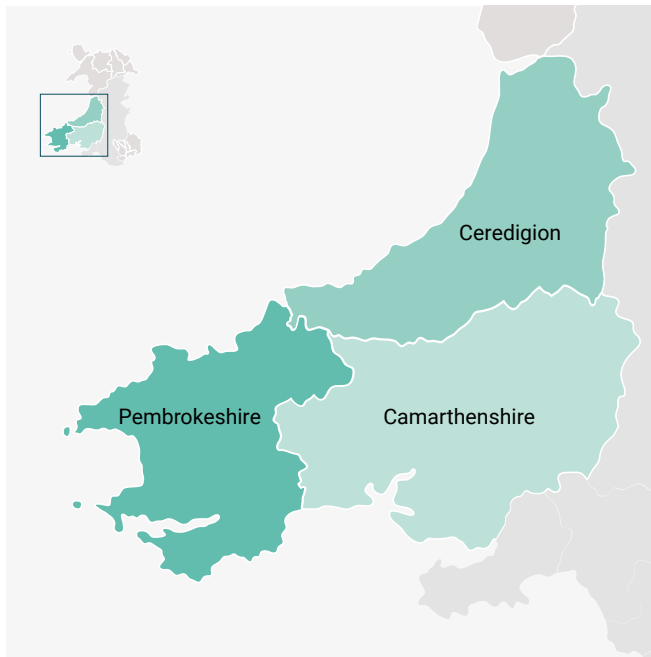
Figure 1 shows the three counties within HDUHB that referred patients to the TEC heart failure programme.

2.3 Rationale and aims of the service

The following aims are specified in the TEC business case for HDDUHB (2021):

• Support pro-active care through home monitoring, highlighting risks before they occur i.e. fall or acute episode.

• Support the independence and wellbeing of our population, by offering help to help themselves in monitoring their health.

• Provide an outlet for a greater holistic approach to health and care needs, linking monitoring platforms to the Delta CONNECT programme.

• Support our design assumptions for the delivery of our strategy, by reducing the need for follow up outpatient appointments, and supporting early discharge.

• Transform the ways of working for our clinicians, by having a seamless monitoring platform, resulting in greater patient experience and impact on capacity.

• Use a Value Based Healthcare approach to inform the requirements of the solution, in parallel with the need for robust measurement of outcome measures & benefits monitoring.

3. Evaluation introduction

Improved quality of life and reduced emergency department attendances are reported benefits of TEC (Mclean et al., 2012), but the method of delivery and cost effectiveness varies and there are a lack of randomised controlled trials (RCT) in this area (Department of Health, 2011). Findings from the Department of Health show that TEC can deliver reductions in A&E visits, emergency admission and bed days, but the results may not be generalisable as there are differences in standard practice between health care providers using TEC (Department of Health, 2011).

The TriTech Institute (https://tritech.nhs.wales/) was commissioned by HDUHB to evaluate the impact of the TEC programme for HF patients across the three counties of the health board. This evaluation was funded internally through HDUHB.

This report covers the evaluation period between June 2021 and October 2022. During this period a total of 232 HF patients were enrolled onto TEC in HDUHB.

3.1 Evaluation aim

The aim of this real-world evaluation was to understand any impact on patients, staff, and the health board infrastructure for TEC use with heart failure patients at HDUHB.

There were five key areas in which data was collected for the evaluation and cross referenced for understanding any potential benefits to the patients.

3.2 Evaluation areas

1. **TEC recruitment and engagement –** The TEC platform stores data on active and pending patients numbers, and the results of physiological measurements. This data was explored to understand the level of patient recruitment and engagement.
2. **Heart failure informatics –** Data relating to HF related hospital admissions and outpatient appointments estimated the impact of TEC on health care utilisation and clinical outcomes us and clinical outcomes.
3. **Patient Reported Outcome Measures (PROMS) –** PROMS were collected by the value-based healthcare (VBHC) team.
4. **Patient feedback –** Patient feedback was obtained through the platform via questionnaire, to understand the attitudes of patients towards TEC.
5. **Staff feedback –** Staff were consulted during the evaluation period to understand any barriers or facilitators to TEC use with HF patients.

4. Methodology

4.1 TEC recruitment and engagement

Patients were recruited onto the TEC service by HF nurses. Patient recruitment criteria were not specified to the HF nurses by more senior health board staff, but they were instructed to select patients from their clinic lists who they thought may benefit from additional monitoring based on their clinical judgement. Once patients were referred into the TEC aspects of the HF service, their details (name, address, contact details) were sent securely to be added onto the TEC platform. Once on this system, call centre staff from Delta Wellbeing could contact patients in order to arrange delivery and setup of the mobile device and peripheral equipment (blood pressure cuff, pulse oximeter and weighing scales) in their home. During these home visits by Delta Wellbeing, training was provided for all devices.

Once patients had equipment installed in their homes, tests were run by staff to determine if patients were able to use the peripheral devices and to log physiological readings successfully (blood pressure, heart rate, bodyweight). If patients had any additional problems at this stage, Delta Wellbeing then conducted follow up visits in the patients home to solve them. At this point the HF nurses were able to use the TEC platform to set expected limits for the various physiological readings (blood pressure, heart rate, bodyweight), so that these limits could be used to flag any results that would constitute a low severity reading (just over/under limit) or a high severity reading (far over/under expected limits). The requests for readings from patients would come from the HF nurses and be sent out through the TEC platform on the same day each week (Monday). All alerts were flagged on the TEC platform and additionally HF nurses and Delta Wellbeing received emails of any notices that they had to action.

Amber alerts on the system would be actioned by call centre support staff at Delta Wellbeing and red alerts would be actioned by the HF nurses. A practical example of this system in action is detailed below:

• Mrs X is requested for a blood pressure reading on the Monday. Mrs X records this successfully, and it is just over the upper limit of what is expected. This would trigger a low severity warning on the TEC platform which would be sent to Delta Wellbeing. They would then call Mrs X to check if she was ok and find out if any help was needed. If at this point Delta had any cause for concern, they could send the details across to the HF nurses.

• Mr Y is requested a reading for body weight on the Monday. He records his weight which is logged through the Mobile platform onto the TEC platform, but his weight is much lower than the expected. This time a high severity warning is sent to the HF nurses where they could follow up over a phone call and then arrange an in-person clinic where necessary.

It is important to note that this was not an emergency service. All patients were advised to follow standard protocols (calling 999) if their health suddenly got worse or were having any symptoms indicating ill health that needed emergency support. Figure 2 shows a visual representation of the flow of data from the patient to either the HF nurses or Delta Wellbeing.

Figure 2 shows the data flow between the patient and the clinician or third-party support where a) patient logs physiological reading into the Mobile App, b) the data is transferred into the TEC platform, where c) readings flagged as high severity are sent to the HF nurses and d) low severity results are sent to Delta Wellbeing.

The following data was available for download and analysis from the TEC platform:

- **Patient recruitment and discharge –** The numbers of patients who were being referred and discharged (because service no longer wanted/needed), from the service.
- **Active patients –** Total number of patients active on the system.
- **Compliancy rates –** Percentage of reading requests successfully responded to by the patient using the Mobile app.
- **Time taken to onboard patients –** The numbers of days taken between patients being referred to the service and installation of the TEC devices with first successful reading request sent to patient.
- **Reading rates –** Number of reading requests sent to patients each week by the HF nurses.
- **Severe readings –** Number of severe readings logged in the TEC platform for each patient.

4.2 Heart failure informatics

The HDUHB informatics team were sent a data request that covered all hospital admissions where a HF diagnosis code was the primary reason for admission. The HF outpatient appointments were also requested. The HF informatics data included patients using TEC and those who were not.

Hospital admissions data included the date of admission and length of stay as well as the primary reason for admission (in these cases HF). The outpatients appointment data related to the HF clinics that were conducted by the specialist nurses in HDUHB, and included the date of attendance, method of attendance (face-to-face or virtual) and priority (routine vs urgent). Patient identifiable information was available as part of the data request from informatics, this data was used to correlate information with data obtained from the TEC platform to determine which patients had used TEC and those who did not. All patient data was anonymised for this evaluation report.

4.3 Patient Reported Outcome Measures (PROMS)

The VBHC team in HDUHB use the DrDoctor platform to request and record PROM responses from patients in a wide variety of clinical areas. The PROMS which were collected for HF patients are discussed below. PROMS were collected using the DrDoctor platform, where patients could complete validated questionnaires sent to the app on patients' phones.

4.3.1 KCCQ-12

The Kansas City Cardiomyopathy Questionnaire, short form (KCCQ-12) is a shorter version of the original 23 item instrument for capturing symptom frequency, physical and social limitations, and quality of life impairments as a result of heart failure. The short form implementation is more feasible to implement than the full instrument whilst preserving the psychometric properties (Spertus and Jones, 2015). Please see appendix 1 for the KCCQ-12 questionnaire and appendix 2 for the scoring guide. For the KCCQ-12 and questions a higher score indicates fewer negative effects associated with heart health (Spertus and Jones, 2015). The minimum clinically important difference (MCID) for KCCQ-12 is reported as ≥9 points for patients with heart failure with reduced ejection fraction (HFrEF) and ≥7 points for patients with heart failure with preserved ejection fraction (HFpEF) (Butler et al., 2022).

4.3.2 PHQ-2

The patient health questionnaire (PHQ-2) is a two-item tool for diagnosing and monitoring depression. Its diagnostic performance is comparable with that of longer depression scales, and can be used for detecting depression, grading its severity, and monitoring outcomes over time (Löwe et al., 2004). The PHQ-2 assesses two items; 'Little interest or pleasure in doing things' and 'Feeling down, depressed, or hopeless both' scored (0 - not at all to 3 nearly every day). The total score can range between 0 and 6 across the two questions, a score of 3 or higher is used when screening to indicate depression (Löwe et al., 2004).

4.3.3 PROMIS 4a

PROMIS (Patient-Reported Outcomes Measurement Information System) is a set of measures for evaluating physical, mental, and social health (PROMIS, 2023). The PROMIS 4a is a 4-question set relating to physical function. A low overall score on the PROMIS 4a would indicate an individual has reduced physical function in their daily tasks.

4.3.4 EQ-5D-5L

The EuroQol 5 domain 5 Level (EQ-5D-5L) validated questionnaire is a PROM used to assess quality of life across 5 domains: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each domain is scored on a 5-level severity ranking that ranges from "no problems" (1) to "extreme problems, unable to do" (5). These 5 domains can be used to calculate an index score representing overall quality of life. The EQ-5D-5L also includes a 'self-score' measure of between 0 (worst) and 100 (best) for how an individual feels their health is overall on that day (EuroQol, 2022). See appendix 3 for the EQ-5D-5L questionnaire.

Since the introduction of the original EQ-5D in 1990, numerous country-specific value sets were produced to elicit preferences from members of the general public about how the domains impact overall quality of life. More recently EuroQol has developed new index value sets for the EQ-5D-5L. A value set does not currently exist for a Wales specific population but there is an English Devlin set that was used for calculations in this study (EuroQol, 2022). Please see appendix 12 for the EQ-5D-5L index table. See appendix 4 EQ-5D-5L index scoring information. The MCID for coronary heart disease with EQ-5D-5L is a change of 0.071 for the calculated index score (Zheng et al., 2023).

4.3.5 WPAI

The work productivity and activity impairment (WPAI) questionnaire is a validated instrument that can be used to measure impairment to work and activities as a result of a health condition (Zhang et al., 2010). The questions in the WPAI are scored lower for less impairments on work and activities, with a higher score indicating more impairments. See appendix 5 for the WPAI questionnaire.

4.3.6 Additional questions and data collected

As part of the PROMS collection in DrDoctor, the VBHC team included an additional two questions about the activity levels of the HF patients. These questions were:

1. What level of activity/exercise did you mainly take last week?
2. Roughly how much times did you spend being active/exercising last week?

4.4 Patient feedback

Patient feedback was obtained using a questionnaire sent out through the TEC platform and the Mobile app as an unscheduled interview monthly between August and October 2022. It was undertaken in this way so that it would not negatively affect the compliancy rates and reading statistics of patients who did not complete it each month it was sent out through the system.

The questions asked of patients related to their telehealth device use and how long they had been using the TEC service. There were also questions relating to their attitudes towards TEC and their self-efficacy for heart failure symptom management. The self-efficacy questions were based on the self-efficacy for chronic disease questionnaire (Ritter and Lorig, 2014). See appendix 6 for the full list of questions sent to patients though the feedback questionnaire.

4.5 Staff feedback

Staff feedback was obtained during project multidisciplinary team (MDT) meetings between health board staff and Delta Wellbeing representatives. Focus groups and staff interviews were also conducted during the project to understand the key challenges faced. A thematic analysis was used to understand key challenges for HF nurses and Delta Wellbeing.

Variable	Carmarthenshire n=128	Ceredigion n=60	Pembrokeshire n=33	p-value
Mean age (years)	72.2 (SD 12.3)	69.4 (SD 11.5)	64.5 (SD 13.7)	<0.01
% male	65.9	56.1	67.7	>0.05

Table 1 shows the mean age and percentage (%) of patients included in the TEC service for the three counties.

Counties	Diff	Lower	Upper	p adj
Ceredigion-Carmarthenshire	-2.799499	-7.438807	1.839809	>0.05
Pembrokeshire-Carmarthenshire	-7.689708	-13.516561	-1.862855	<0.01
Pembrokeshire-Ceredigion	-4.890209	-11.376157	1.595738	>0.05

Table 2 shows the Tukey test results for testing for differences between the three counties in terms of age.

5. Findings

The results and subsequent discussion for this evaluation follow four themes:

- Patient outcomes and feedback.
- Technology accuracy and usability.
- Barriers and facilitators in clinical infrastructure
- Staff feedback.

Each theme identifies key factors that influence the potential impacts of TEC use in HF patients.

5.1 TEC recruitment and engagement

Table 1 shows the mean age and percentage (%) male demographics for patients from each of the three counties included in the TEC evaluation. An ANOVA was used to test for differences between counties in terms of age, with a p-value <0.05 a difference was detected. A Chi-Squared test was used to test for differences between the counties in terms of % male, but none was detected (p>0.05).

As a difference in age between the counties was detected, a Tukey test was used to check the between county differences. From the results in table 2 it can be seen that Pembrokeshire HF TEC patients were younger than those in Carmarthenshire (p adjusted <0.01).

Figure 3 shows the cumulative patient referrals for the TEC HF service across all three counties between June 2021 and October 2022. This graph shows patient referrals during the evaluation and does not indicate when patients were discharged from the TEC service. Appendix 7 shows the cumulative number of HF patients referred to the service by month as raw data. A steady increase in total patients referred to the TEC HF service was seen for all three counties during the course of the evaluation. Carmarthenshire had

the highest number of referrals to the service by October 2022 with 133. This was followed by Ceredigion and Pembrokeshire which had 65 and 34 referrals respectively. 232 patients were referred in total across all three counties, 200 of which had data available on the TEC platform (32 either declined the service after being referred or withdrew for other reasons).

Figure 4 shows the TEC HF patient recruitment by county and month. This metric is non-cumulative and shows recruitment each month independently throughout the evaluation period. Appendix 8 shows the non-cumulative patient recruitment as raw data. Recruitment numbers peaked in August 2021 when all three counties were fully set up with the TEC platform and Delta Wellbeing were able to install and connect the devices in patients' homes.
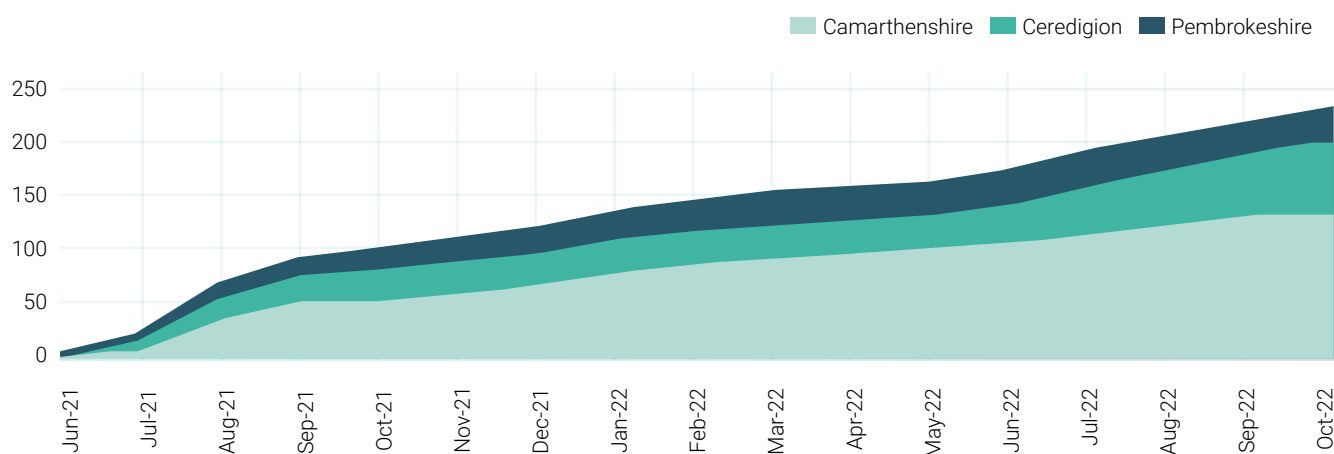
Figure 3 shows the cumulative patient recruitment by month across all three counties.
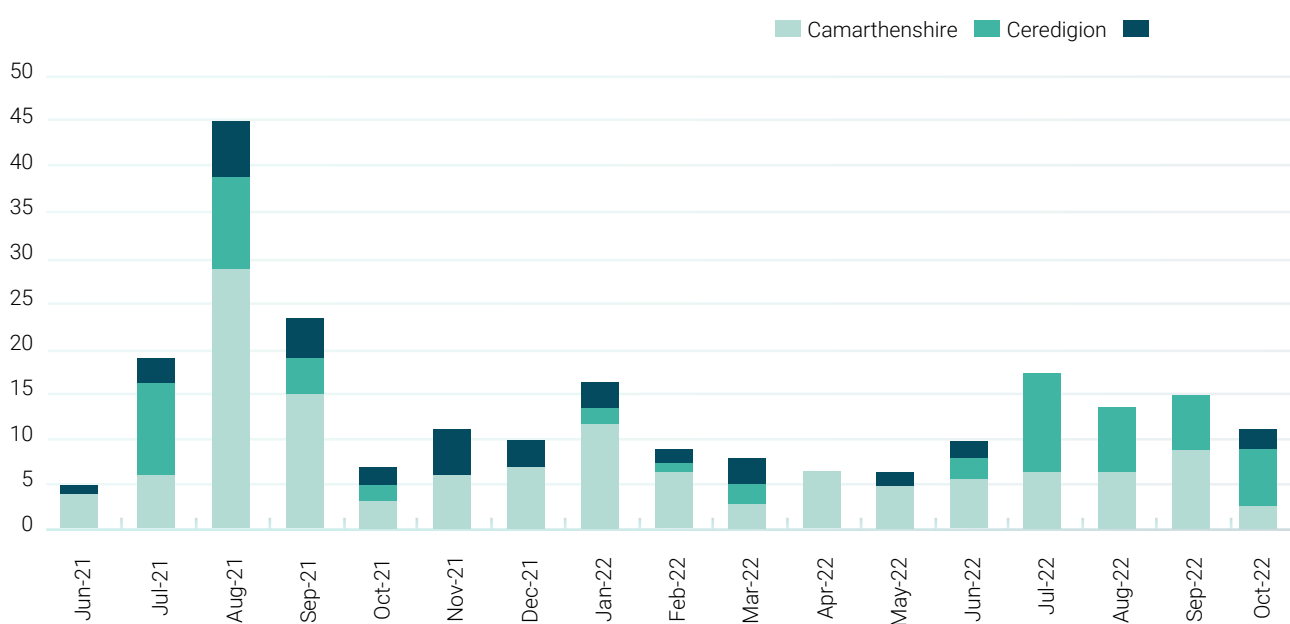
Figure 4 shows the non-cumulative patient recruitment by month across all three counties.

Figure 5 shows the patient discharges from the TEC service by month across all three counties. This represents patients who were no longer able to receive reading requests through the Mobile device, but who were still under the regular care pathway for HF. Appendix 9 show the patient discharges raw data. The first patients were discharged from the TEC HF service in May 2022, after discussions during MDT meetings highlighted a growing number of patients not actively using the devices.

Figure 6 shows the TEC HF recruitment across all three counties as a total with discharged patients removed from the total. This metric was the active patients on the system who were able to receive reading requests to their Mobile device. Appendix 10 shows the active patients raw data.

August 2021 see the first patients to become active on the TEC platform, at which point active patients numbers continued to increase until July 2022, at which point all three counties were beginning to discharge patients and one nurse from Ceredigion began increasing TEC use in the service. This increase can be seen in figure 6 in August and September 2022. There was a decrease in Ceredigion active patient numbers in October 2022, this was due to an increased discharge of inactive patients in that month (seen in figure 5). The increased discharge rate at Ceredigion was due to one of the nurses allocating time to work on TEC one day a week, this led to an increased understanding of which patients need to be removed due to lack of usage or benefit. A similar change was not seen Carmarthenshire and Pembrokeshire around this time.
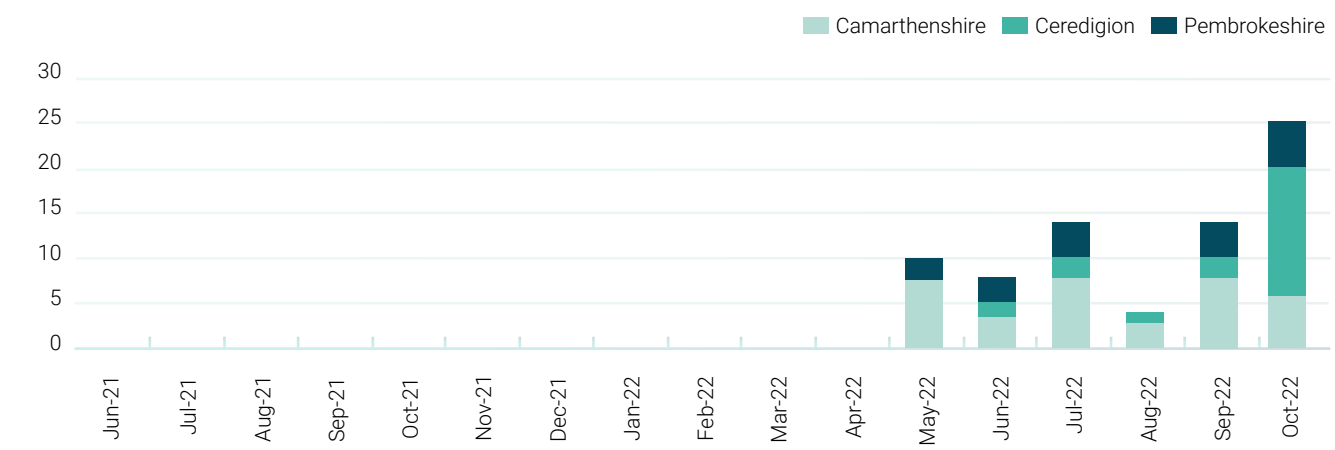
Figure 5 shows TEC HF patient discharges by month across all three counties.
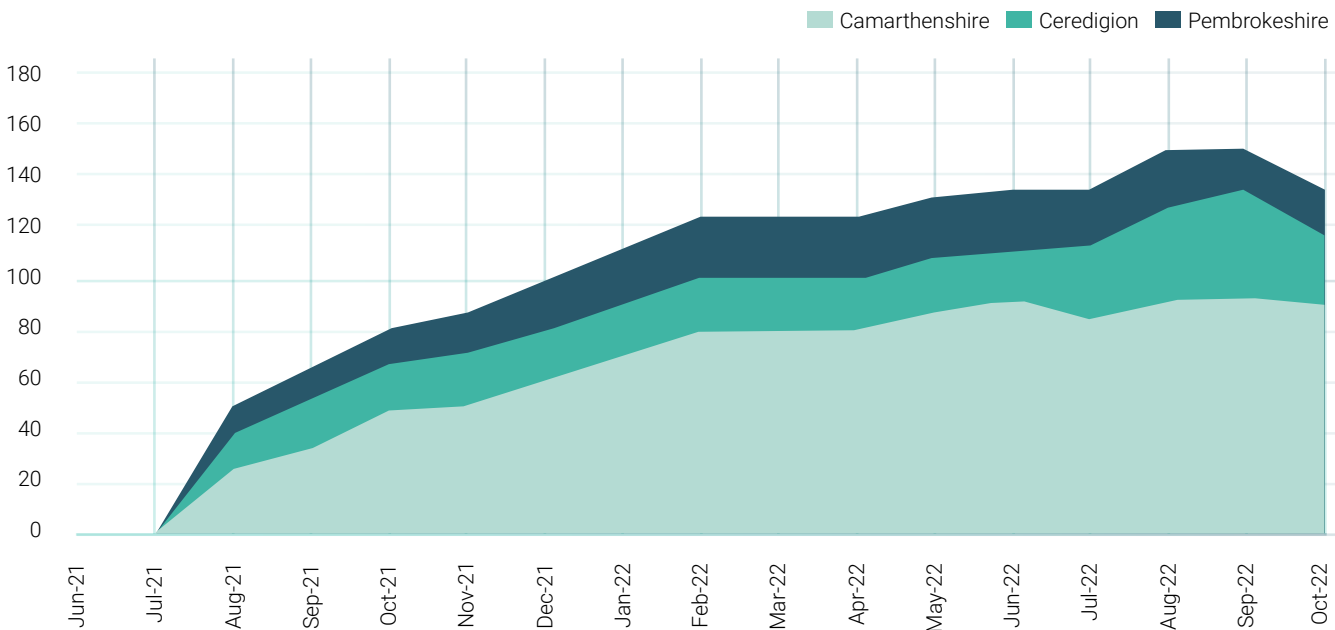
Figure 6 shows TEC HF Active patients by month across all three counties.

There were differences between the three counties in terms of recruitment rates and discharge. This could be explained by the size and patient throughput between the counties. One of the heart failure nurses in Ceredigion took on a more active role with TEC around June 2022, which was reflected in the recruitment and discharge rates. Pembrokeshire had higher reading rates than Carmarthenshire and Ceredigion, it is unclear from the data why this may have been. There is not currently a recommended reading rate, it would be worth exploring the possibility of an ideal reading rate, but this could be influenced by various factors such as condition severity or the presence of comorbidities. Pembrokeshire also had higher compliancy rates between October 2021 and Jun 2022, which could be related to the increased reading rates.
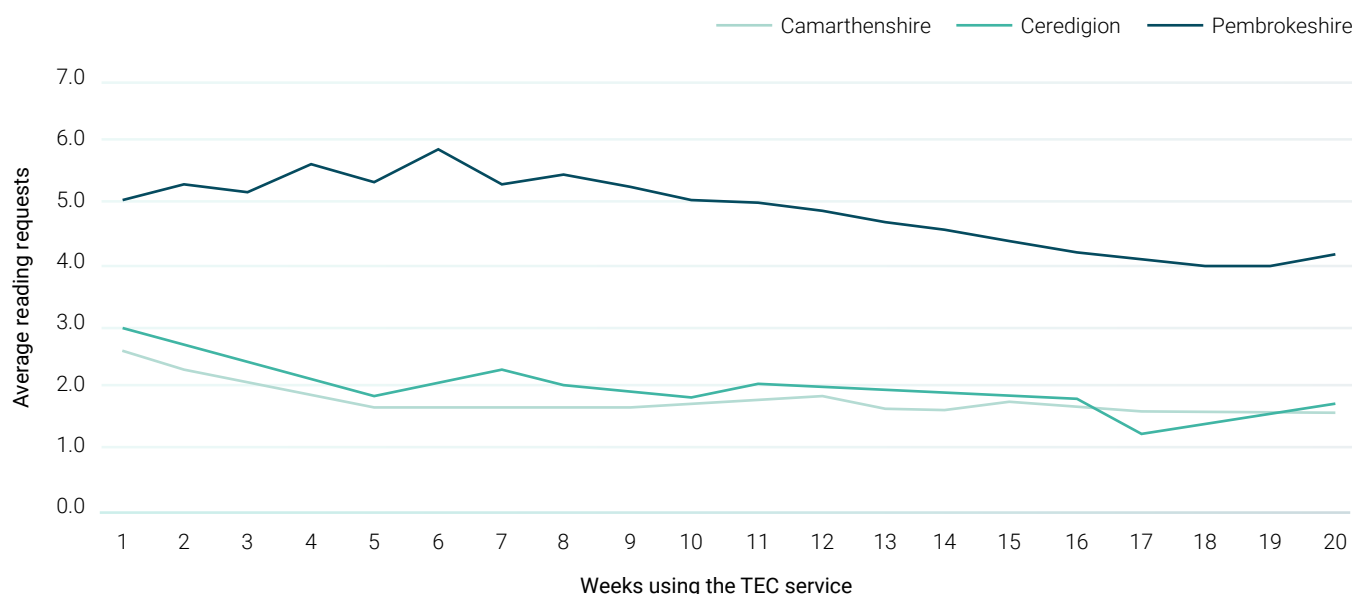
Figure 7 shows TEC HF reading rates as an average across patients for each of the three counties by weeks of TEC service.

Figure 7 shows reading rates as an average (mean) across patients by number of weeks using the TEC devices. This data is from 197 patients across all three counties (Carmarthenshire 115, Ceredigion 53, and Pembrokeshire 29) whose data was available on the TEC platform. Appendix 11 shows the reading rates by week raw data. Pembrokeshire consistently had more reading requests per patient than both Carmarthenshire and Ceredigion, it was not clear following focus groups with staff why his might have been. No recommendations were given to the HF nurses in any county about how many reading requests should be sought each week. All three counties had a slightly higher reading rate request on average at week 1 compared to week 20. More reading requests were required in the first 1 or 2 weeks for patients being setup on the TEC service, this helped both the patient and Delta Wellbeing to troubleshoot any issues.

Figure 8 shows compliancy as an average (mean) across patients by number of weeks using the TEC devices. This data is from 200 patients across all three counties (Carmarthenshire 115, Ceredigion 53, and Pembrokeshire 29) whose data was available on the TEC platform. Appendix 12 shows the compliancy by week raw data. All three counties had an increase in compliancy rates on average between weeks 1 and 4, this was due to the patients becoming accustomed to using the devices.

Figure 9 shows the patient compliancy rates as a percentage (%) of readings successfully responded to on the Mobile device each month by county. The compliancy rates raw data can also be seen in appendix 13. This data is by month of project, with individual patients being onboarded and receiving reading requests at different months of the project. There were fluctuations in compliancy rates across all three counties, but the overall trend (in particular Carmarthenshire and Ceredigion) for compliancy was decreasing between January 2022 and April 2022. The overall compliancy rates started to increase in July after users were discharged from the service in May and June 2022 (see figure 5).
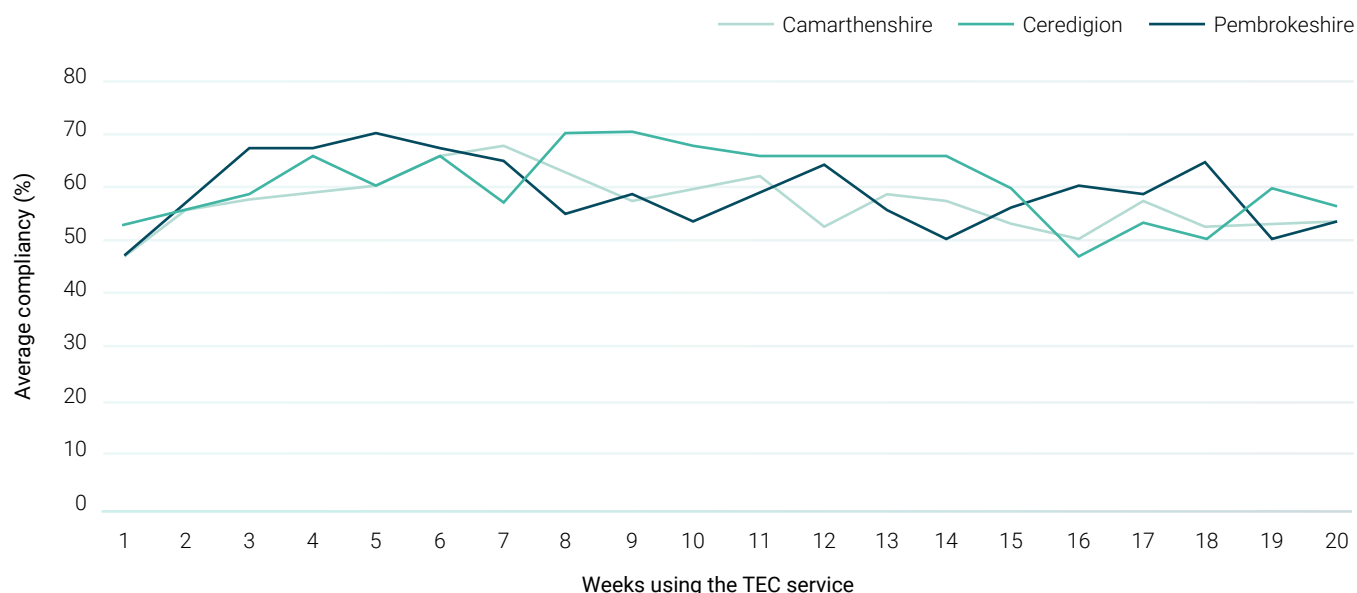
Figure 8 shows TEC HF compliancy as an average across patients for each of the three counties by weekss of TEC service.
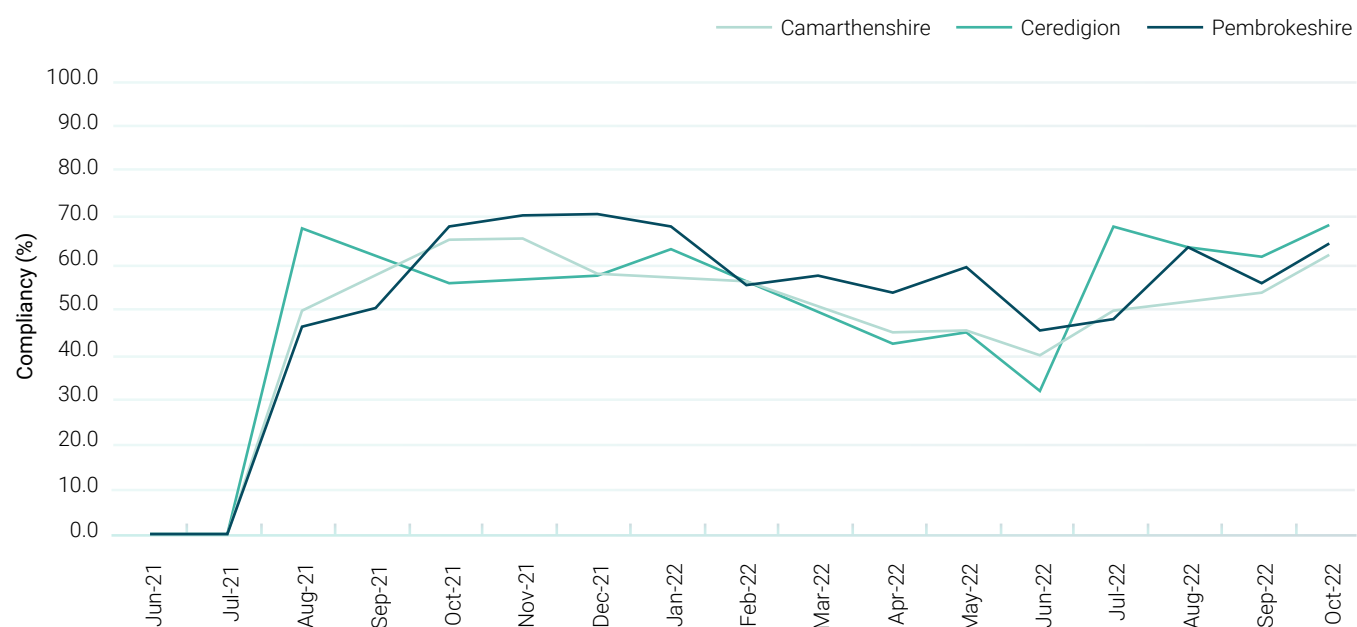
Figure 9 shows TEC HF compliancy rates by county and month.

Figure 10 shows time to onboard patients for TEC HF. This graph indicates the average number of days across all three counties between a patient being referred to the TEC service and for the first reading request to be sent to the patients' mobile device. HDUHB set a target for 5 days as the maximum time to onboard patients. Figure 10 excludes patients who took longer than 30 days to receive the first reading request as outliers. Despite fluctuations, the overall trend to onboard patients was decreasing during the evaluation period.

There was a target of 5 days between patient referral and getting the devices into a patients home. The overall trend was towards this with an average of 6 days across all counties by October 2022. The average at the start of the evaluation period in June 2021 was 16 days. There were many factors that contributed to delays in getting the patients set up with the devices, many related to the quality of information available to Delta Wellbeing.
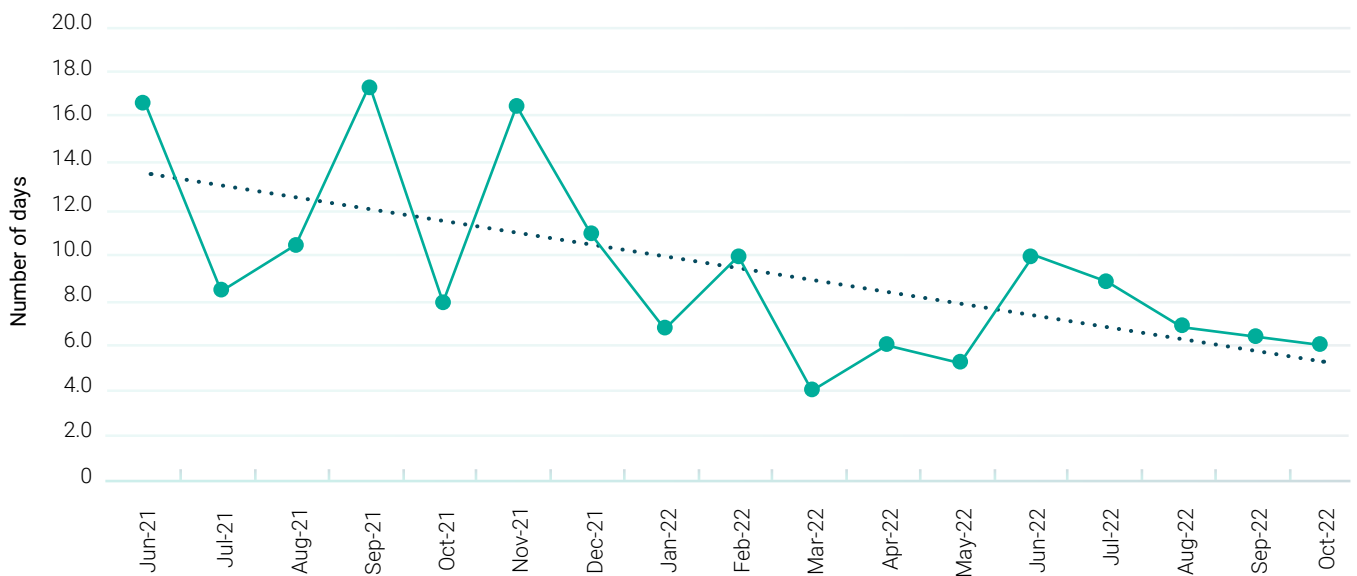
Figure 10 shows the average time taken for patients to receive their first reading requests through the mobile device.

Table 3 shows summary data for patient discharge, compliancy rates, and time to onboard each month and the mean number of reading requests by each week of patient TEC use. An ANOVA was used to calculate differences in the variables between the three counties. No differences between the counties were detected for discharge percentage, average compliance rates or the time to successfully onboard patients (devices working in the home). A difference was detected in the average number of reading requests each week ($P<0.001$), where Pembrokeshire were requesting more readings than Carmarthenshire of Ceredigion.

Variable	Camarthenshire Mean (SD)	Ceredigion Mean (SD)	Pembrokeshire Mean (SD)	p-value
Proportion of patients discharged from TEC from active patient list per month	2.36 (3.67)	4.35 (10.9)	4.73 (9.0)	>0.05
Average compliance rates (%)	53.7 (7.07)	56.2 (9.9)	58.2 (8.8)	>0.05
Mean time to onboard (in days) each month	8.99 (3.53)	9.49 (4.2)	9.74 (6.05)	>0.05
Mean no. reading requests each week of patient TEC use	1.43 (0.242)	1.64 (0.453)	4.5 (1.21)	<0.001

Table 3 shows summary information for the percentage (%) of patients discharged each month, overall monthly compliance rates (%), average time taken to onboard each month and mean number of readings by week of TEC use for all three counties.

5.2 Heart failure informatics

During the period of 4th May 2021 to 31st October 2022, there were a total of 1464 hospital admissions related to HF and 6173 HF outpatient clinic appointments. This data includes all patients using the TEC service and those who were not. Table 4 shows the summary statistics for hospital admissions and outpatient appointments for this period. 'Occurred whilst using TEC' indicates hospital admission and outpatient data relating to patients using TEC at the time of occurrence. 'Non-TEC related' indicates the data relating to patients who had never used TEC at all, or those that had used TEC at some point, but were not active on the system during the occurrence.

Variable	Occurred whilst using TEC	Non-TEC related
Median bed days per hospital admission (n)	2	4
Face to face outpatient appointments n (%)	143 (26.6%)	2432 (43.2%)
Virtual outpatient appointments n (%)	395 (73.4%)	3192 (56.6%)
Routine outpatient appointments n (%)	457 (84.9%)	4890 (86.8%)
Urgent outpatient appointments n (%)	81 (15.1%)	743 (13.2%)

Table 4 shows the median bed days for hospital admissions and face to face/virtual and routine/urgent data for outpatient appointments. This relates to occurrences for patients using TEC and those that occurred for patients whilst not using the technology (standard care or before/after TEC involvement).

There was a (significance not tested due to small numbers of TEC related admissions) difference in median bed days associated with patients active on TEC (2 bed days) when compared to non-TEC related admissions (4 bed days).

But the TEC related admissions was only a small sample (8 individual admissions). A larger data set would be required to determine if the service has a statistically significant effect on hospital length of stay. The ratio of face-to-face and virtual outpatient appointments for HF patients on TEC was 143 face-to-face (26.6%) and 395 virtual (73.4%). For non-TEC patients this ratio was 2314 face-to-face (43.2%) and 3028 virtual (56.6%) This indicates that patients enrolled on TEC were travelling to physical clinics less often. The ratio of routine to urgent appointments for HF patients was 81 urgent (15.1%) and 457 routine (84.9%). For non-TEC patients this ratio was 705 urgent (13.2%) and 4646 routine (86.8%).

The odds ratio and confidence intervals (CI) for virtual/in-person clinics and urgent/routine appointments between TEC and non-TEC use can be seen in table 5. Patients using TEC were 2.1 times more likely to be seen for virtual outpatient clinics than patients not using TEC (p<0.001).

Variable	Odds ratio	Lower CI (95%)	Upper CI (95%)	p-value
Virtual / In-Person	2.1	1.73	2.57	<0.001
Urgent / Routine	1.17	0.91	1.49	>0.05

Table 5 shows the Odds Ratio (OR), upper and lower confidence intervals (CI) and significance values (p) for virtual/in-person and urgent/routine outpatient appointments for TEC and non-TEC patient groups.

Figure 11 shows TEC patient recruitment by month of the evaluation, this displays the trend across the three counties throughout.

Figure 12 shows the hospital admissions by month of evaluation as a total across all three counties. The data in figure 12 is separated into non-TEC, before/after TEC and during TEC. A decrease in hospital admissions can be seen during June 2022 that persists until October 2022.

The active TEC patients and cumulative TEC recruitment variables do not change as abruptly as the hospital admissions (as can be seen in figure 11) but this information alone is not enough to relate the TEC recruitment to changes in overall hospital admissions data. There are very few hospital admissions in patients who were active on TEC, and this did not increase as more patients were recruited and made active on the TEC service. This data can also be seen in appendix 14.
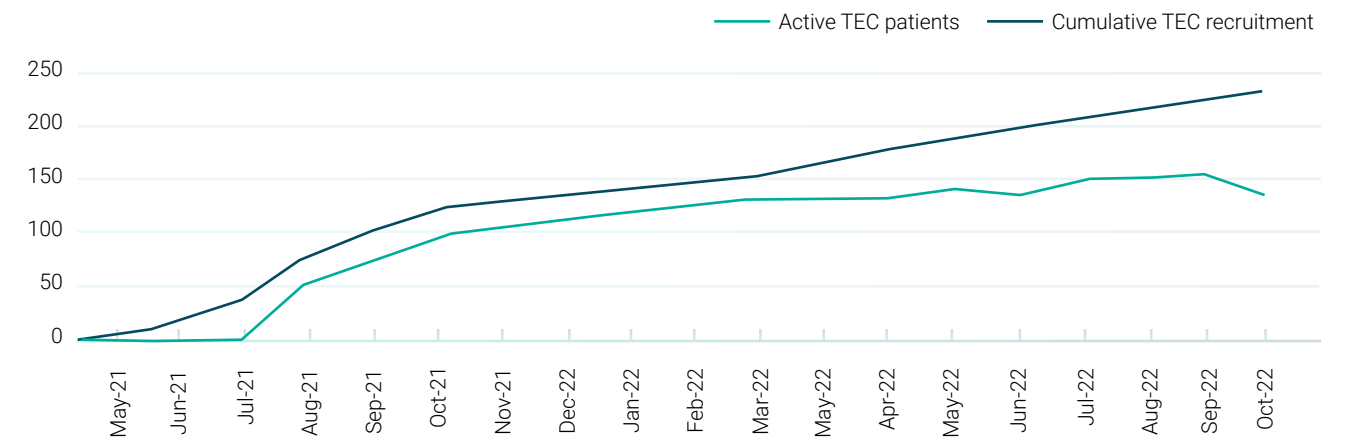
Figure 11 shows the TEC recruitment by month of evaluation as a total across all three counties.
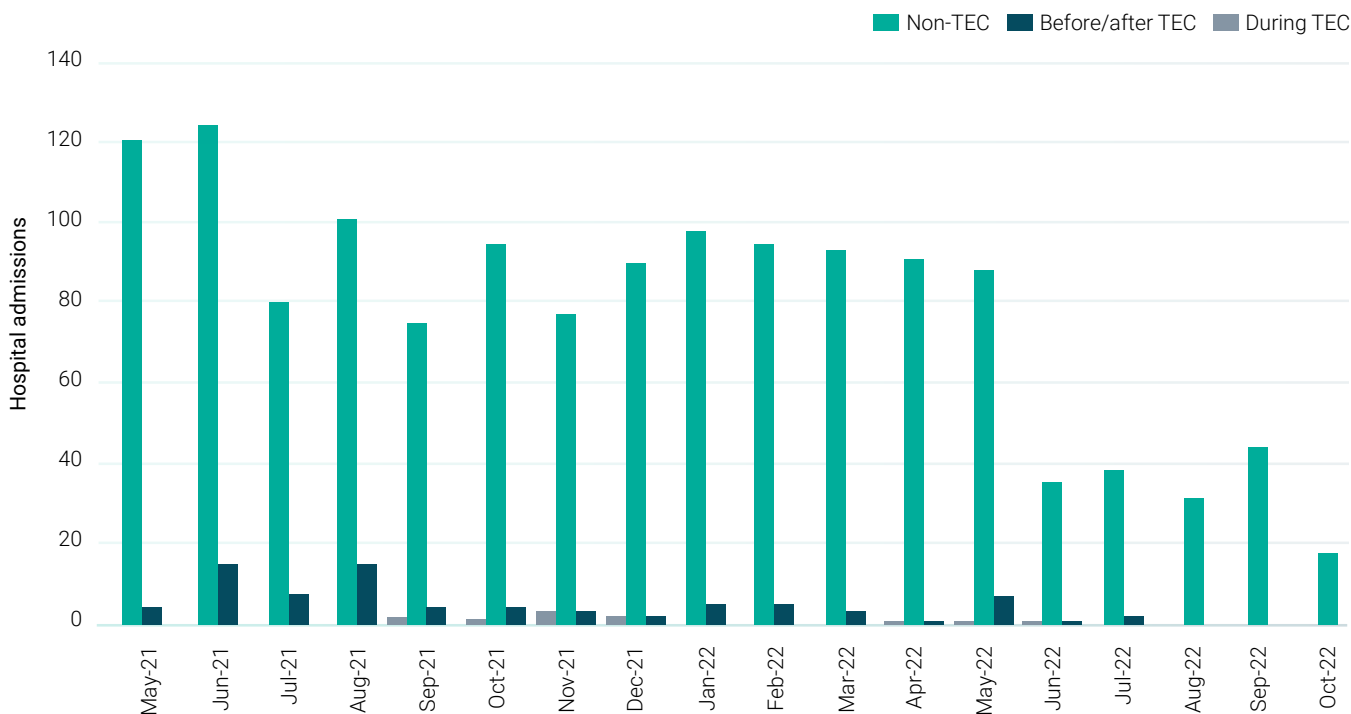
Figure 12 shows the hospital admissions by month of evaluation as a total across all three counties.

Figure 13 shows outpatient appointments by month of evaluation as a total across all three counties. The data in figure 13 is separated into non-TEC, before/after TEC and during TEC. Outpatient appointments increased from July 2022, discussions during MDT indicated that additional HF staff were hired by the health board which accounts for this increase. This data can also be seen in appendix 15.

Pearson's correlation coefficients were calculated between TEC recruitment, patient compliancy, hospital admissions data and outpatient appointment data. The data used for these correlations is in appendix 14 and appendix 15, for hospital admissions and outpatient appointments respectively. Patient compliancy data by month can be found in appendix 13.
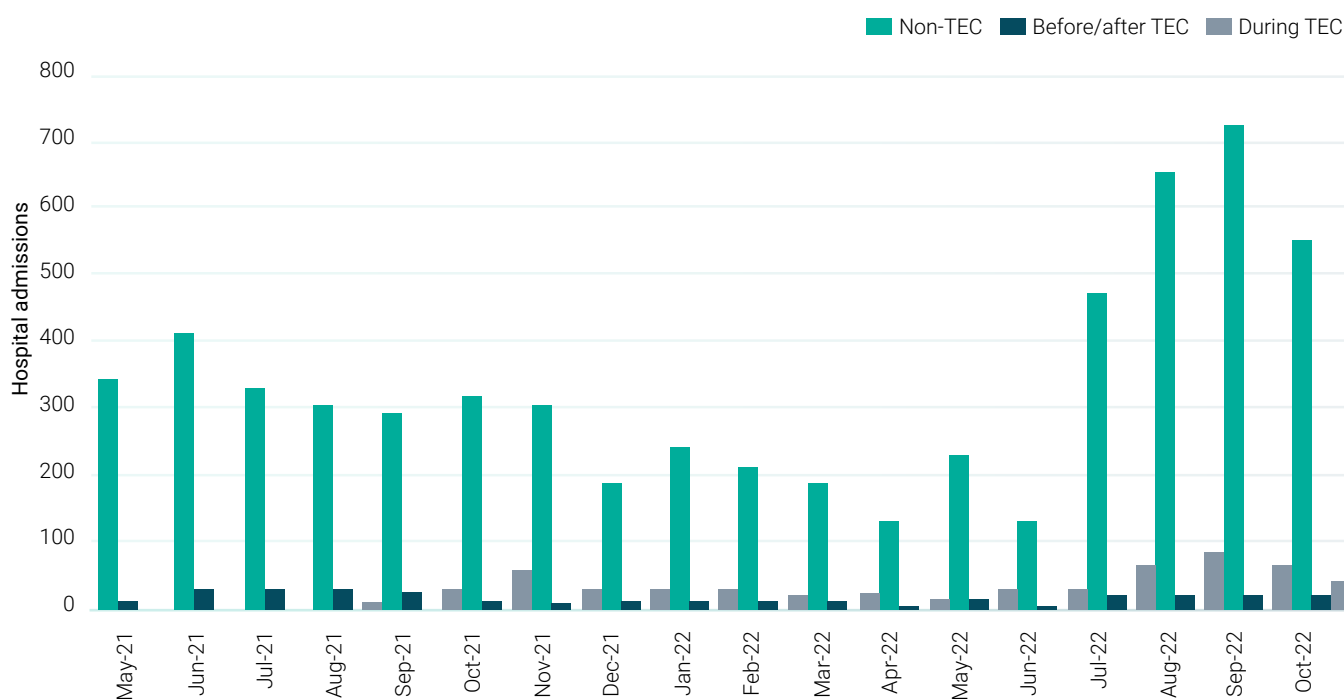
Figure 13 shows the outpatient appointments by month of evaluation as a total across all three counties.

Table 5 shows the calculated Pearson correlation coefficients between TEC recruitment (non-cumulative), average compliancy, total hospital admissions, total outpatient appointments (all, non-TEC, and TEC) by month of evaluation. Correlations that were statistically significant are highlighted as (*significance < 0.05) and (**significance < 0.01).

Where a statistically significant result exists, we cannot infer a cause and effect relationship, without knowing if any third factors could be influencing the results. But the results in table 6 did indicate the following:

1. Outpatient appointments for patients using TEC correlated highly significantly and inversely with all hospital admissions (P = -0.79, significance < 0.0001).

2. Outpatient appointments for non-TEC also correlated significantly with a reduction in hospital admissions (P = -0.51, significance = 0.0325).

3. There was no correlation between monthly TEC recruitment rates (onboarding) and average compliancy rates to hospital admissions or outpatient appointments.

Data from all counties show a negative correlation between outpatient appointments and hospital admissions. This indicates that as more patients are seen in outpatient appointments, HF related hospital admissions decrease. During the evaluation period this was most evident June/July 2022 where admissions dropped, and outpatient appointments increased. More staffing resources in HF were made available at this time which is an important confounder.

	Hospital admissions	Outpatient appointments (no TEC)	Outpatient appointments (TEC)	Outpatient appointments (all)	TEC recruitment	Average compliancy
Hospital admissions	1.00					
Outpatient appointments (no TEC)	(-0.51*)	1.00				
Outpatient appointments (TEC)	(-0.79**)	(0.66**)	1.00			
Outpatient appointments (all)	(-0.56*)	(1.00**)	(0.72**)	1.00		
TEC recruitment	-0.06	0.14	0.01	0.13	1.00	
Average compliancy	0.04	0.40	0.25	0.38	0.01	1.00

Table 6 shows Pearson's correlation coefficients between TEC recruitment (non-cumulative), average compliancy, hospital admissions and outpatient appointments (all, non-TEC, and TEC) by month of evaluation.

5.2.1 HF informatics (TEC only)

To investigate any medium-term associations of TEC use on hospital admissions and outpatient appointments, patients who had been enrolled on TEC for at least 6 months were identified. We excluded patients with 'a new to service appointment' within 6 months of starting TEC use and patients whose 6 months of TEC use overlapped with the HF staffing increase that occurred during July 2022. This was to reduce any bias in increase outpatient appointment numbers that happened as a result of the extra capacity. This filtered data resulted in a list of 61 patients, which can be seen in appendix 16.

Using this outpatient appointment data, a Wilcoxon rank sum test with continuity correction was calculated. This was to test for differences in outpatient appointment rates between 6-months pre and 6-months post TEC referral. Figure 14 shows the outpatient frequency data for the 6-month pre and post TEC referral period for the these 61 patients.

Similarly, hospital admissions data was filtered for TEC patients only, also including only patients who had used the TEC service for 6 months. Patients who had overlapping TEC use with the staffing increase in July 2022 or being 'new to service' were removed for this part of the analysis. This resulted in 55 patients with applicable data. Figure 15 shows this hospital admission data for pre and post TEC referral. Data can be found in appendix 17.

Wilcoxon rank sum tests were used to calculate the differences between 6-months before and 6-months after TEC referral for these patients for outpatient appointments and hospital admissions.

When considering patients who had used the TEC service for a period of 6 months and comparing against the previous 6 months; there was no overall difference in outpatient appointment rates ($p>0.05$), but there was a reduction in hospital admissions when patients were using the TEC service ($P=<0.05$).

To explore other factors and potential confounders in the data, pairs plots (appendix 18) and linear correlation coefficients and plots (appendix 19) were produced for; age, sex, weeks using TEC, device compliancy, reading rate (total number of reading requests/total number of weeks on TEC), severe reading rate (total number of severe readings / total number of reading requests), number of admissions pre-TEC and on TEC and number of outpatients pre-TEC and on TEC.

Figure 14 shows the outpatient frequency across the months of TEC use for patients.
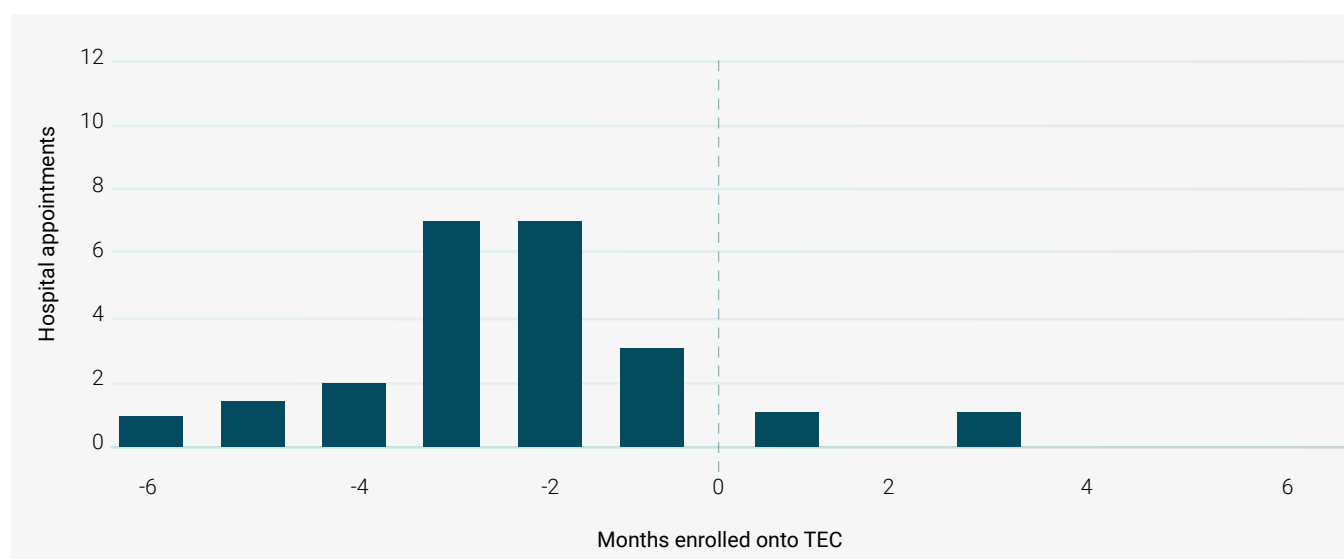
Figure 15 shows the hospital admissions across the months of TEC use for patients, 'new' patients have been removed.

There was a moderate correlation (corr = 0.423, p<0.01) between total number of weeks using TEC and outpatient appointments whilst using TEC (as seen appendix 19). This may indicate that patients who had more outpatient appointments as a result of using the technology during a 6-month period ended up using it longer beyond this period.

Another moderate correlation was detected between device compliancy and the severe readings rate (corr = 0.313, p<0.01) as seen appendix 19. Feedback from clinical staff involved in the evaluation indicated that it was not known what would influence a patients compliance to the technology. So a multi-regression was calculated with the dependent variable being device compliancy and the

predictors including other TEC factors. The histogram of variances and residual vs fitted model diagrams from this multi-regression can be seen in appendix 20. Table 7 shows the results from the multi-regression model calculations.

From this regression analysis the adjusted R-Squared value was 0.1903 and had a p-value of <0.001. Number of weeks using TEC and the severe reading rate may factor into the variations in compliancy rates for patients. Number of weeks using TEC is going to have a more obvious impact on compliancy rates as patients using it longer will become more familiar with the technology. The relationship between compliancy and severe reading rates requires further exploration.

Variable	Odds ratio	Lower CI (95%)
Sex	0.986	0.325
Age	-1.599	0.111
Weeks using TEC	4.097	5.96×10^{-5}***
Reading rate	-0.150	0.881
Severe reading rate	4.823	2.71×10^{-6}***
Hospital admissions pre-TEC	1.049	0.295
Hospital admissions on TEC	0.253	0.800
Outpatient appointments pre-TEC	-0.716	0.475
Outpatient appointments on TEC	1.298	0.196

Table 7 shows the coefficients, standard error and predictive value of the multi-regression model using device compliancy as the dependent variable. *** indicates a significance value of <0.001

5.3 Patient Reported Outcome Measures (PROMS)

Appendix 21 shows a summary of the PROMS that were collected during the evaluation, via the DrDoctor platform. This summary also includes abbreviations used in the calculations of differences between groups. Two additional questions regarding activity levels and demographic and TEC device use information were included in appendix 21 along with data regarding outpatient appointments.

5.3.1 TEC compared to non-TEC PROMS
Wilcoxon signed rank tests were used to compare the differences between median responses to PROMS for patients using TEC and those who had not. Table 8 shows the variables in which a difference between TEC and non-TEC patients was detected. Where the median value was the same for both groups, the mean value was used to indicate the difference between them.

These findings suggest that patients enrolled on TEC had more restrictions in daily activities and chores and decreased ability to visit friends and family when compared to patients not using TEC. This could also be a factor in the reduced interest or pleasure doing things (PHQ-2) for the TEC patients.

There were differences in PROMS between patients who were enrolled onto TEC and those who were not. These differences were not deemed a result of TEC use as the data used in the calculations included responses from patients before they used TEC. The differences between PROMS for TEC and non-TEC patients indicated that patients using TEC were reporting less vigorous activity levels, higher symptom frequency, more restrictions on their ability to see family and friends and more difficulty with daily mobility. The HF nurses may have been intuitively selecting patients that were less able to leave the home as candidates for TEC in the absence of patient selection criteria.

Variable	TEC Median	TEC Mean	Non-TEC Median	Non-TEC Mean	p-value
Exercise intensity	2	1.75	2	1.95	<0.001
Social limitation score (KCCQ-12)	37.5	50	N/A	N/A	<0.05
Walking on level ground (KCCQ-12)	3	2.84	3	3.22	<0.05
Interest in doing things daily (PHQ-2)	1	1.34	1	1.10	<0.05
PROMIS 4a summary score	11	N/A	13	N/A	<0.01
Quality of life index score (EQ-5D-5L)	0.68	N/A	0.74	N/A	<0.05

Table 8 shows the median and mean values for variables in which a difference was detected between the TEC and non-TEC groups. The p-value of significance for these differences is also included in this table.

5.3.2 TEC only patient PROMS analysis

PROMS data available through the DrDoctor platform. Data was non-parametric so median responses across all PROMS were calculated where patients had completed them more than once. Patient PROM responses were correlated against TEC related factors which were; average compliancy, number of weeks using TEC, reading request rates, severe reading rates rate and outpatient appointment rates (see appendix 21 for a summary of all PROMS). Pearson's correlation coefficient was calculated in R Statistics and the results can be found in appendix 22, notable findings from appendix 22 can be seen in table 9.

Factor 1	Factor 2	Correlation	p-value
Device compliancy	Exercise intensity	0.34	0.01
Device compliancy	Patient age	-0.27	<0.05
Severe reading rate	Patient age	0.3	<0.05
Severe reading rate	Device compliancy	0.34	<0.05
Number of weeks using TEC	Device compliancy	0.27	<0.05
Outpatient appointment rate	Number of weeks using TEC	-0.41	<0.01

Table 9 shows the TEC and patient demographic factors where a correlation was detected. This table shows the Pearson's correlation value (P) and the significance level (p).

Appendix 23 shows the correlation results for TEC factors and median patient results for the PROMS outlined in appendix 21. Notable findings when comparing TEC factors and median PROMS results can be seen in table 10.

Factor 1	Factor 2	Correlation	p-value
Swelling on ankles (KCCQ-12)	Severe reading rate	-0.31	0.02
Shortness of breath (KCCQ-12)	Outpatient appointment rate	0.29	0.032
Anxiety (EQ-5D-5L)	Number of weeks using TEC	-0.29	0.031

Table 10 shows the TEC and PROMS factors where a correlation was detected. This table shows the Pearson's correlation value (P) and the significance level (p).

When considering the PROMS results for patients using TEC, younger patients who exercised at higher intensities were more likely to respond to reading requests (compliancy) (p = 0.049 and p = 0.01). There was also an association between younger patients and the likelihood for severe readings (p = 0.027), but increased compliancy was also associated with increased severe readings (p = 0.011). An association (-0.31) was also detected between the occurrence of swelling of ankles, feet, and legs and severe reading rates (0.02), indicating that as reported swelling increases (lower score on KCCQ-12) the rate of severe readings also increases.

Variable	TEC survey responders	TEC survey non-responders	p-value
Sex (% Male)	66.6%	60.1 %	>0.05
Age (Mean and SD)	68.9 (SD = 11.3)	70.15 (SD = 12.44)	>0.05
County (% split between Carmarthenshire /Ceredigion/Pembrokeshire)	53/26/21%	58/27/15%	>0.05

Table 11 shows the sex, average age and county split for the TEC patients who responded to the survey feedback and those that did not. The p-values are also indicated on this table.

5.4 Patient feedback

Appendix 24 shows the demographic and TEC service use information for the 42 responders to the survey. The patient questionnaire was only available during the last 3 months of this evaluation period, at which active patients on the TEC platform peaked at 154 in September 2022. This meant a response rate of only 27.3%.

To understand if the 42 patients who completed the feedback questionnaire were representative of the rest of the TEC patient cohort, a comparison was made between the sex and treatment county for both of these groups and can be seen in table 11. The information for sex and county of treatment for all patients involved in TEC HF can also be found in appendix 24. Chi-squared tests were used to test for differences in sex and county split and a t-test was used to test for difference in age. As can be seen in table 11, no significant differences were detected between TEC patients responding to the survey and those who did not, for sex, age or split across the three counties.

The patient responses to "How long have you been using the TEC HF service", "How often are you using the Mobile device?", "How often are you contacted about the TEC HF service"? and "Do you need help using the TEC devices?" can be seen in figures 16, 17, 18, and 19 respectively.
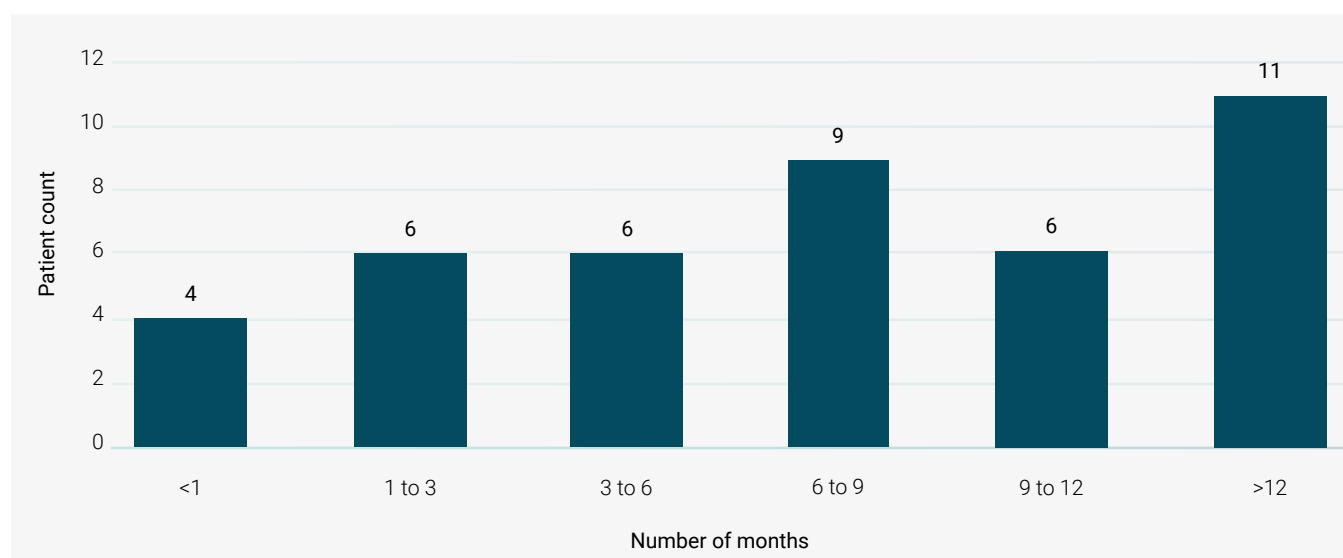
Figure 16 shows the number of months the questionnaire responders had indicated they had been using the TEC HF service.
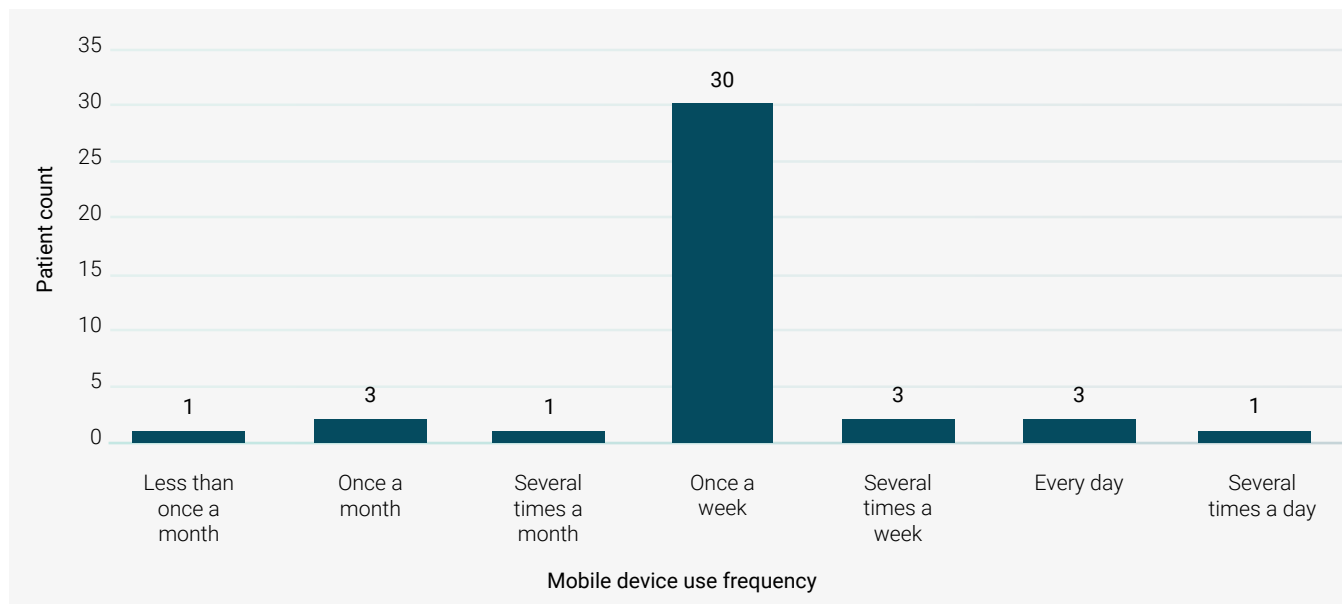
Figure 17 shows the frequency of use for the mobile device of questionnaire responders.
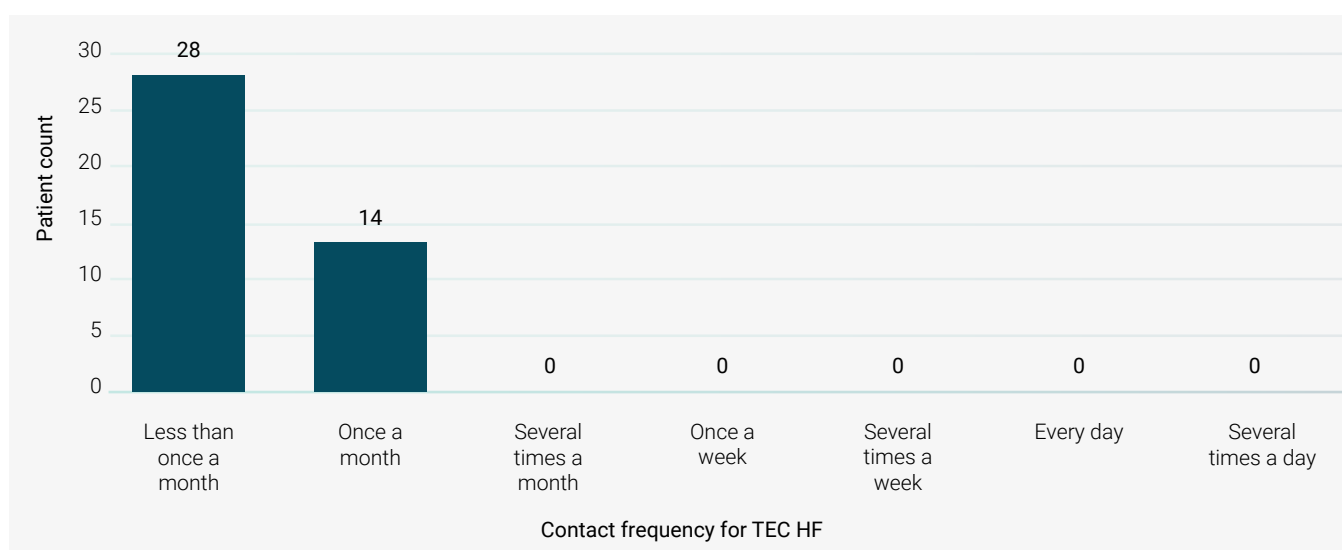
Figure 18 shows the frequency in which questionnaire responders were contacted in relation to the TEC HF service.
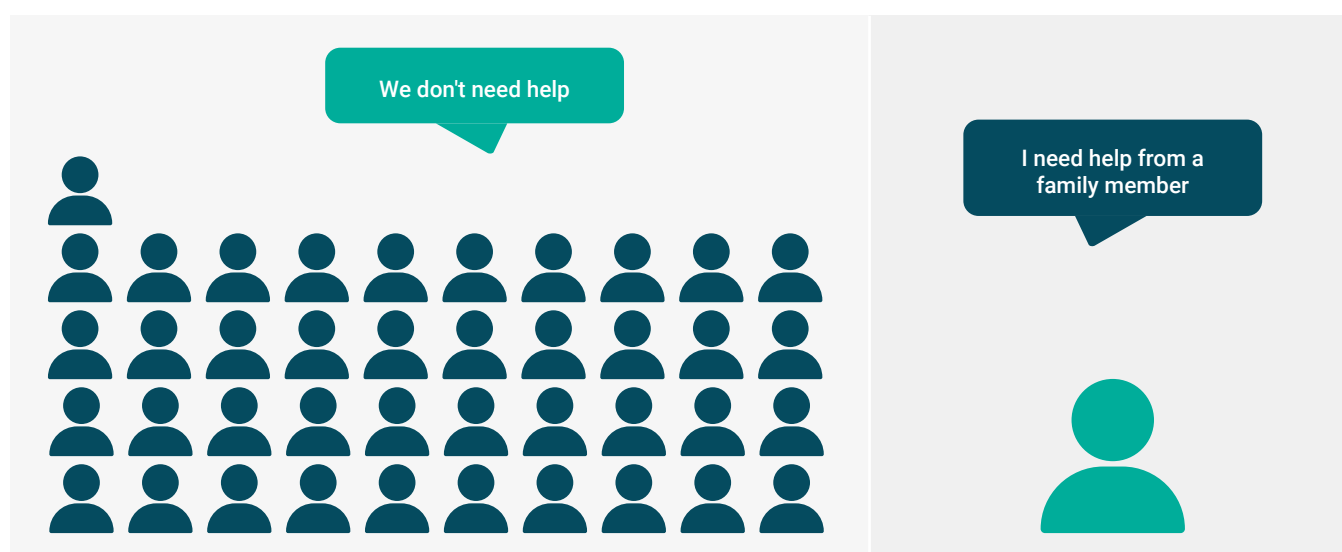
Figure 19 shows the responses relating to assistance required when operating the TEC devices. Only one reported needed assistance.

Technology Enable Care (TEC) Heart Failure | version 1.0 | March 2024

Appendix 25 shows the patient feedback questionnaire responses relating to their thoughts on the TEC service. The Likert scale patient responses found in appendix 25 can also be seen in figure 20.

Appendix 26 shows the patient survey feedback relating to their heart health and how they manage their condition. One of the questions in this section of the survey was relating to the New York heart failure classification (appendix 6). Figure 21 shows the distribution of patients across the 4 New York heart failure classifications as reported.

	Strongly disagree	Strongly disagree	Neutral		Agree	Strongly agree
I am confident in the accuracy of the device readings		2%	2%	2%	62%	26%
I had enough training on how to use the telehealth devices			2%	7%	67%	24%
I am confident that someone is monitoring the data			5%	5%	69%	21%
I think this technology will help the NHS to improve my health care			2%	7%	62%	29%
I like to use the internet to look for ways to support my own health	5%	10%	7%		62%	17%
I know how to tell the difference between good and bad health advice online				10%	76%	14%
My own internet or WiFi connection speed if good	2%	5%	12%		62%	19%

Figure 20 shows the Likert scale response percentages to questions relating to the TEC HF service and their internet use for supporting their own health.
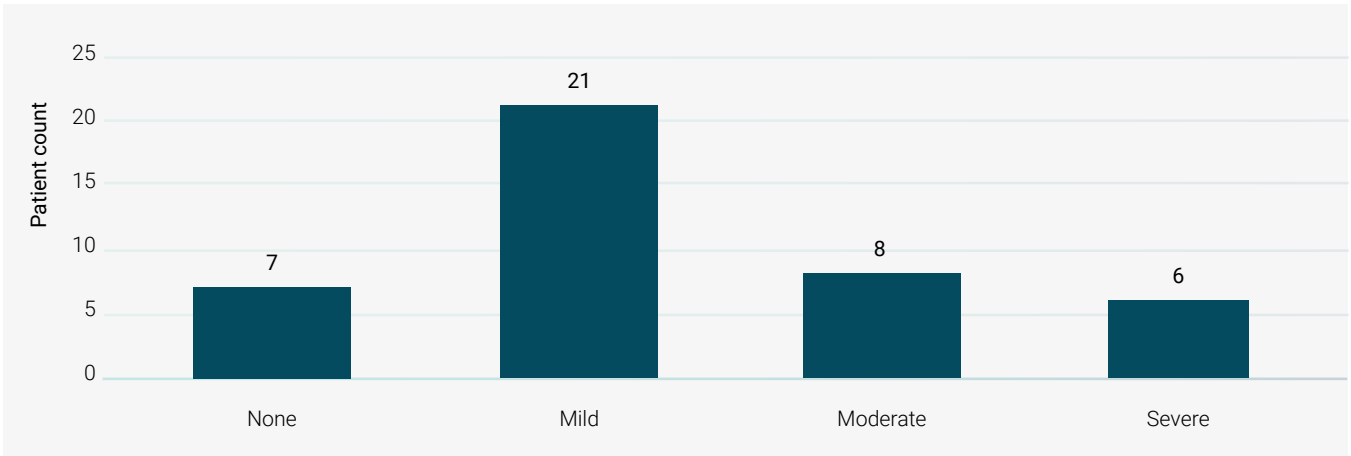
Figure 21 shows the New York heart failure classification responses of patients who responded to the feedback questionnaire.

5.5 Staff feedback

An MDT meeting occurred during November 2021, where HF nurses and staff from Delta Wellbeing were in attendance.

Figure 22 shows the main summary comments from the HDUHB HF nurses from the MDT focus group in November 2021. There was a concern that using the TEC platform could interfere with their usual clinical work, and that it took time to log into and out of the system. There were also concerns about clinical responsibility for the patients using TEC and who would be held responsible if a patient alert was missed, which resulted in harm. At this stage there were a lot of questions about the system and how

to effectively use it, there was also a lack of awareness about some of the features available.

Figure 23 shows the summary comments from Delta Wellbeing from the MDT in November 2021. Delta Wellbeing staff had difficulty setting up patients with the devices in their homes, a lot of this was related to incorrect contact details for patients or not having information on when they may be home. Alerts were generated based on physiological readings from patients, but the severity of these alerts would depend on the parameters set by the clinical staff, when set incorrectly it meant that Delta Wellbeing were unable to respond to reading requests as they could have been showing up as severe needing clinical input.

Figure 22 shows summary feedback comments from HDUHB HF nurses during an MDT meeting, November 2021.

There was also a lack of understanding at the start of the MDT meeting in November 2021, regarding what others see in the system. The HF nurses did not know what Delta Wellbeing could see on their side and vice versa. Neither

the nurses nor Delta were sure how the system looks from the patient's perspective. Staff showed examples of this to everyone on screen during the MDT, to clarify what each party would be able to see and action.
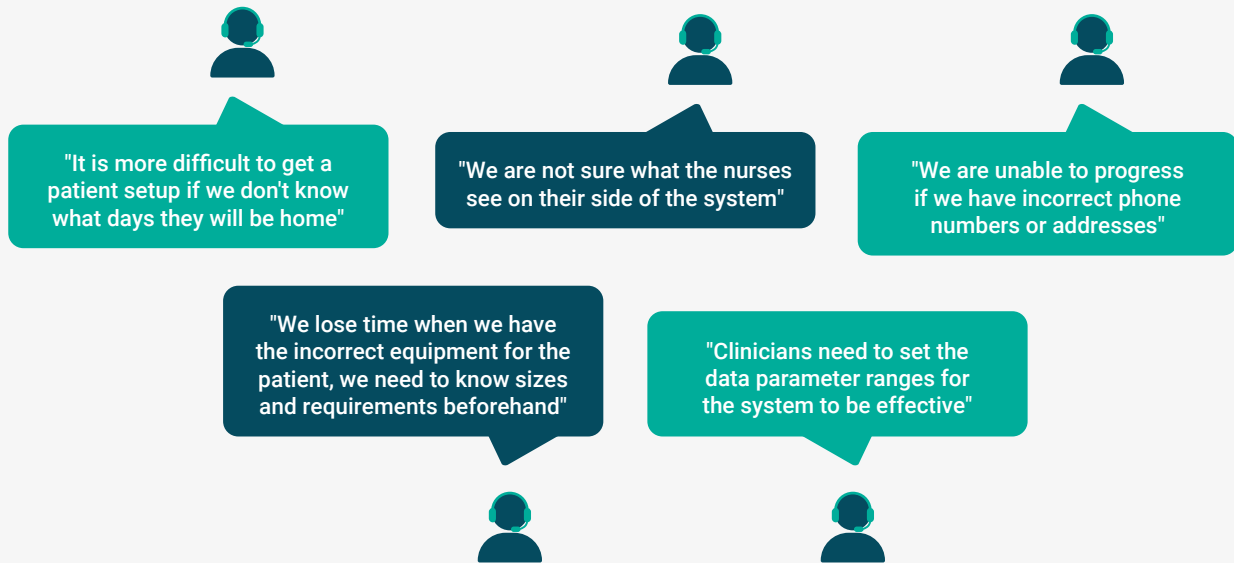
Figure 23 shows summary feedback comments from Delta Wellbeing staff during an MDT meeting, November 2021.

Further staff feedback was obtained through small focus groups and interviews with HDUHB HF nurses and Delta Wellbeing staff, between January and March 2022. Figures 24 and 25 show the key summary messages from the HDHUB HF nurses and Delta Wellbeing respectively. These sessions were conducted separately to reduce any potential influence that one group could have had on the other in the MDT approach.

Figures 24 and 25 show the feedback from the interviews and focus groups conducted between January and March 2022. Some of the feedback and comments were the same as those recorded during the MDT in January 2021, such as not being aware of the system from other team perspectives and logistical issues with getting patients set up. More in-depth feedback was obtained from the nurses as well, they felt less ownership of the project as they initially had to recruit patients quickly whilst not being consulted about how best to run the service.

Following all feedback as of March 2022, a further MDT meeting was scheduled to help resolve some of these long-standing issues. This second MDT meeting was conducted in April 2022, and was more practical in nature. One of the HF nurses shared their screen and described issues they were experiencing so that Delta Wellbeing staff could help resolve. Summary points from the MDT meeting in April 2022 can be seen below.

Figure 24 shows key feedback messages from HDUHB HF nurses during focus groups and interviews held between January and March 2022.

Hywel Dda University Health Board (HDUHB)

- The company produced documents and leaflets to raise awareness of the Mobile platform and its features, these were very helpful for the clinical staff who requested copies to discuss with their patients.

- The HF nurses requested additional information relating to how patients handle additional reading requests (the company were to implement new information into their leaflets).

- HF nurses committed to adding more information onto the referrals to make it easier for Delta to make contact with patients.

- HF nurses needed more clarification about how to handle alerts when they should be handled by Delta Wellbeing. This was discussed using a real patient on the system which helped everyone on the call.

- HF nurses were still unsure about the accuracy of the pulse oximeters used.

Delta Wellbeing

- Staff confirmed that the HF nurses and Delta staff see the same interface when logged in to the TEC platform.

- The company have created the Mobile platform awareness leaflet and presentation materials which have helped both the HF nurses and Delta Wellbeing, these were also updated following the feedback in the April 2022 MDT meeting.

- There was a suspected cyber-attack within the TEC platform system which was triggered by a large numbers of users trying to log in at the same time, this resulted in the system being unavailable for a period of time. This login threshold was going to be changed to avoid this happening again.

- Delta were going to investigate how best to inform patients of the procedure regarding their helpline, as many of them were being directed to the wrong teams when needing assistance.

The HF nurses were initially unsure of the service, but made it work as best as they could. There was a lack of clinical buy-in from the clinical teams as they did not feel consulted before it was rolled out.

There were some genuine concerns from the HF nurses about the clinical responsibilities for the patients using TEC. An SOP for TEC use in HF would be welcomed by the clinical staff, to help differentiate the responsibilities when considering alerts and severity of readings. Staff were concerned about adding more patients onto TEC and then missing information or warnings that could lead to patient harm. The TEC service was not intended to replace emergency or standard care procedures, but an SOP could help HF staff and third-party organisations (Delta Wellbeing) run the service more effectively and safely long term.

There was a lack of (or breakdown in) communication between staff from the Health Board and Delta Wellbeing during various stages of the evaluation. This resulted in HF nurses not knowing when patients had been added onto the system and Delta Wellbeing having difficulty with installations. Towards the later stages of the evaluation period, all parties involved began taking steps to improve the process so that the service would run more smoothly. These suggestions and discussions came from MDT meetings which were not frequent. Regular and structure MDT meetings between all parties may continue to improve service efficiency.

Figure 25 shows key feedback messages from Delta Wellbeing during focus groups and interviews held between January and March 2022.

6. Discussion

6.1 Infrastructure factors

When considering patients who had used the TEC service for a period of 6 months and comparing against the previous 6 months; there was no overall difference in outpatient appointment rates ($P>0.05$), but there was a significant reduction in hospital admissions ($P<0.05$).

Patients using TEC were 2.09 times more likely than those not using TEC to have a virtual outpatient appointment, meaning less travel for patients and less need for clinic space for these appointments.

Data from all counties in the health board for heart failure show a relationship between outpatient appointments and hospital admissions. Whereas more patients were seen in outpatient appointments, HF related hospital admissions decreased. During the evaluation period this was most evident during June/July 2022 where hospital admissions dropped, and outpatient appointments increased. This coincided with an increase in staffing resources in HF at this time. The number of TEC related outpatient appointments also correlated with the rate of hospital admissions ($r = -0.79$, $P<0.01$), indicating that overall clinic and nursing staff availability is an important confounder.

6.2 Patient factors

Patient responses to the feedback questionnaire were generally positive. Patients reported they received adequate training in using the TEC devices. Patients also reported they believed the TEC equipment was accurate and would help with their care.

The patients who responded to the feedback questionnaire were mainly being contacted by Delta either once a month or less than once a month. Only one from 42 patients reported that they need help from family members to use the telehealth devices. In general compliancy rate (usage) of TEC increased between week 1 and 4 as they became accustomed to the technology and there was a strong association between compliancy and staffing numbers.

6.3 Staff factors

The HF nurses were initially unsure of the service but made comments that they believed they made it work as best as they could. The clinical teams said they did not feel consulted before the service was rolled out. There were some genuine concerns from the HF nurses about the clinical responsibilities and governance surrounding patients using TEC. An SOP for TEC use in HF would be welcomed by the clinical staff, to help differentiate the responsibilities when considering alerts and severity of readings.

There was a lack of (or breakdown in) communication between staff from the health board and Delta Wellbeing during various stages of the evaluation. Feedback from both of these teams, indicated communication issues, a mixture of technology issues and both teams not having a clear indication of what the other could see on the system or how they were actioning patient alerts. This resulted in HF nurses not knowing when patients had been added onto the system and Delta Wellbeing having difficulty with installations. Towards the later stages of the evaluation period, all parties involved began taking steps to improve the process so that the service would run more smoothly. These actions included new documentation for patients and staff, more call centre staff and training from Delta Wellbeing, and additional referral information from the HF nurses to help with device installations. Clearer lines of communication and responsibility as well as adequate staffing must be considered in any future TEC service.

6.4 Technology factors

There were concerns from the HF nurses surrounding the accuracy of the devices, in particular the pulse oximeters and the inability for them to detect AF. It was reported by the nurses that being able to detect AF in the community would decrease the risk of it going undetected for a longer period than if they were just seen in clinic as per standard care.

Many of the HF nurses reported login issues with the TEC platform. The two-factor identification process was seen as too time consuming in some cases. Being automatically logged out if the nurses stepped away for more urgent tasks was also a frustration. There was an incident that was flagged as a cyber-attack by the system when too many staff members tried to login at once. This resulted in a period where the system could not be used. This was rectified with a 24-hour period where the upper limit of simultaneous logins allowed was raised.

7. Conclusion

The main positive findings from this evaluation show that increased TEC use and increased outpatient contacts are associated with fewer hospital admissions. The resource saving implication of more patients being seen virtually than in clinic is also a positive finding. An economic assessment would be required to quantify if this resource saving is cost effective against the outlay (and maintenance) of equipment, Delta staff time, HF time and ongoing licensing costs.

Clearer guidance on inclusion and exclusion criteria, and lines of delegation of responsibilities for HF nurses and third-party organisations such as Delta Wellbeing were missing.

This real-world approach to evaluation captured data that showed insights into the TEC service for HF patients, but further work would benefit from a more structured approach in which both TEC and non-TEC patients are completing PROMS and feedback at specific time points. More work needs to be undertaken to understand the importance of compliancy (%) and reading rates for optimal patient outcomes.

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Appendices

Appendix 1 – KCCQ-12 Questionnaire

Cardiomyopathy Questionnaire (Kansas City) (KCCQ-12)

The following questions refer to your **heart failure** and how it may affect your life. Please read and complete the following questions. There are no right or wrong answers. Please mark the answer that best applies to you.

1. **Heart failure** affects different people in different ways. Some may mainly feel shortness of breath while others mainly fatigue. Please indicate how much you have been limited by **heart failure** (for example, shortness of breath or fatigue) in your ability to do the following activities over the past 2 weeks.

Please place an **X** in one box on each line

Activity	Extremely limited	Quite a bit limited	Moderately limited	Slightly limited	Not at all limited	Limited for other reasons or did not do the activity
Showering/Bathing	❏	❏	❏	❏	❏	❏
Walking 1 block on level ground	❏	❏	❏	❏	❏	❏
Jogging or hurrying (as if to catch a bus)	❏	❏	❏	❏	❏	❏

2. Over the past 2 weeks, how many times did you have **swelling** in your feet, ankles or legs when you woke up in the morning?

Every morning	3 or more times a week, but not every day	1-2 times a week	Less than once a week	Never over the past 2 weeks
❏	❏	❏	❏	❏

3. Over the past 2 weeks, on average, how many times has **fatigue** limited your ability to do what you wanted?

All of the time	Several times a day	At least once a day	3 or more times a week but not every day	1-2 times a week	Less than once a week	Never over the past 2 weeks
❏	❏	❏	❏	❏	❏	❏

4. Over the past 2 weeks, on average, how many times has **shortness of breath** limited your ability to do what you wanted?

All of the time	Several times a day	At least once a day	3 or more times a week but not every day	1-2 times a week	Less than once a week	Never over the past 2 weeks
❏	❏	❏	❏	❏	❏	❏

5. Over the <u>past 2 weeks</u>, on average, how many times have you been forced to sleep sitting up in a chair or with at least 3 pillows to prop you up because of **shortness of breath**?

Every night	3 or more times a week, but not every night	1-2 times a week	Less than once a week	Never over the past 2 weeks
❏	❏	❏	❏	❏

6. Over the <u>past 2 weeks</u>, how much has your **heart failure** limited your enjoyment of life?

It has **extremely** limited my enjoyment of life	It has limited my enjoyment of life **quite a bit**	It has **moderately** limited my enjoyment of life	It has **slightly** limited my enjoyment of life	It has **not limited** my enjoyment of life at all
❏	❏	❏	❏	❏

7. If you had to spend the rest of your life with your **heart failure** the way it is <u>right now</u>, how would you feel about this?

Completely dissatisfied	Mostly dissatisfied	Fairly satisfied	Mostly satisfied	Completely satisfied
❏	❏	❏	❏	❏

8. How much does your **heart failure** affect your lifestyle? Please indicate how your **heart failure** may have limited your participation in the following activities <u>over the past 2 weeks</u>.

Please place an **X** in one box on each line

Activity	Extremely limited	Quite a bit limited	Moderately limited	Slightly limited	Not at all limited	Limited for other reasons or did not do the activity
Hobbies, recreational activities	❏	❏	❏	❏	❏	❏
Working or doing household chores	❏	❏	❏	❏	❏	❏
Visiting family or friends out of your home	❏	❏	❏	❏	❏	❏

Appendix 2 – KCCQ-12 Scoring

- **KCCQ-12 (Summary Score) =>** (Physical limitation score + Symptom frequency score + QoL score + Social limitation score) / 4 [Higher score indicates better heart health]
- **KCCQ-12 (Physical limitation score) =>** Question 1 (3 parts) is scored 1 (Extremely limited) to 5 (not limited at all), 3, 1s would give 0 SL score and 2 5s would give 100 [Higher score indicates fewer physical limitations due to heart health]
- **KCCQ-12 (Symptom frequency score) =>** Takes into account Questions; 2 (scored 1 (every morning) to 5 (not in past 2 weeks); 3 (scored 1 (all of the time) to 7 (never over the past two weeks); 4 (scored 1 (all of the time) to 7 (never over the past two weeks); 5 (scored 1 (every night) to 5 (not in past 2 weeks). Each of these four questions is then a 0 to 100 scale depending on 1-5 or 1-7 scale, the average of the four questions is the symptom frequency score [Higher score indicates less symptom frequency relating to heart health]
- **KCCQ-12 (Quality of life score) =>** Takes into account Questions; 6 (scored 1 (Extreme limitation to enjoyment of life) to 5 (no impact on enjoyment of life) and 7 (scored 1 (completely dissatisfied) to 5 (completely satisfied). These two questions is then a 0 to 100 scale depending (1-5 scale), the average of the two questions is the quality-of-life score [Higher score indicates better quality of life considering heart health]
- **KCCQ-12 (Social limitation score) =** Question 8 (3 parts) is scored 1 (Extremely limited) to 5 (not limited at all), 3, 1s would give 0 SL score and 2 5s would give 100 [Higher score indicates less social limitation relating to heart health]

Appendix 3 – EQ-5D-5L Questionnaire

Under each heading, please tick the ONE box that best describes your health TODAY.

MOBILITY

I have no problems in walking about ☐

I have slight problems in walking about ☐

I have moderate problems in walking about ☐

I have severe problems in walking about ☐

I am unable to walk about ☐

SELF-CARE

I have no problems washing or dressing myself ☐

I have slight problems washing or dressing myself ☐

I have moderate problems washing or dressing myself ☐

I have severe problems washing or dressing myself ☐

I am unable to wash or dress myself ☐

USUAL ACTIVITIES *(e.g. work, study, housework, family or leisure activities)*

I have no problems doing my usual activities ☐

I have slight problems doing my usual activities ☐

I have moderate problems doing my usual activities ☐

I have severe problems doing my usual activities ☐

I am unable to do my usual activities ☐

PAIN / DISCOMFORT

I have no pain or discomfort ☐

I have slight pain or discomfort ☐

I have moderate pain or discomfort ☐

I have severe pain or discomfort ☐

I have extreme pain or discomfort ☐

ANXIETY / DEPRESSION

I am not anxious or depressed ☐

I am slightly anxious or depressed ☐

I am moderately anxious or depressed ☐

I am severely anxious or depressed ☐

I am extremely anxious or depressed ☐

- We would like to know how good or bad your health is TODAY.

- This scale is numbered from 0 to 100.

- 100 means the best health you can imagine.
  0 means the worst health you can imagine.

- Please mark an X on the scale to indicate how your health is TODAY.

- Now, write the number you marked on the scale in the box below.

YOUR HEALTH TODAY =

The best health
you can imagine

100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
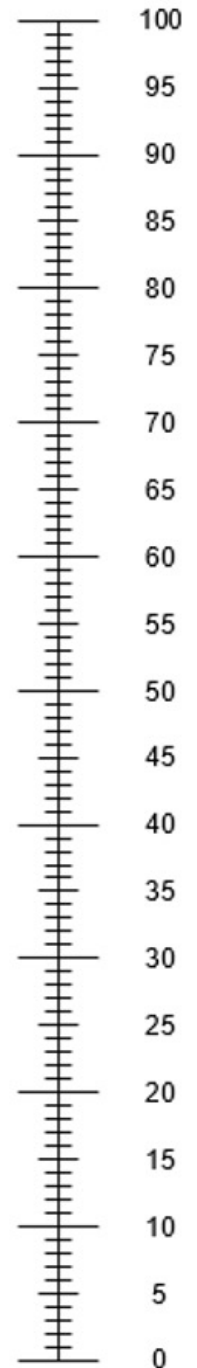
The worst health
you can imagine

Appendix 4 – EQ-5D-5L Scoring

Score	Mobility	Self-care	Usual activities	Pain / Discomfort	Anxiety / Depression
1 (None)	0	0	0	0	0
2	0.058	0.05	0.05	0.063	0.078
3	0.076	0.08	0.063	0.084	0.104
4	0.207	0.164	0.162	0.276	0.285
5 (Extreme problems)	0.274	0.203	0.184	0.335	0.289

Index score reference table for the 5 domains of the EQ-5D-5L.

The equation for calculating the index score is as follows:
EQ-5D-5L Index=1-(Mobility+Selfcare+Activities+Pain+Anxiety)

Appendix 5 – WPAI Questionnaire

**Work Productivity and Activity Impairment Questionnaire:
General Health V2.0 (WPAI:GH)**

The following questions ask about the effect of your health problems on your ability to work and perform regular activities. By health problems we mean any physical or emotional problem or symptom. *Please fill in the blanks or circle a number, as indicated.*

1. Are you currently employed (working for pay)? _____ NO _____ YES
   If NO, check "NO" and skip to question 6.

The next questions are about the **past seven days**, not including today.

2. During the past seven days, how many hours did you miss from work because of your health problems? *Include hours you missed on sick days, times you went in late, left early, etc., because of your health problems. Do not include time you missed to participate in this study.*

   _____HOURS

3. During the past seven days, how many hours did you miss from work because of any other reason, such as vacation, holidays, time off to participate in this study?

   _____HOURS

4. During the past seven days, how many hours did you actually work?

_____HOURS *(If "0", skip to question 6.)*

5. During the past seven days, how much did your health problems affect your productivity <u>while you were working</u>?

Think about days you were limited in the amount or kind of work you could do, days you accomplished less than you would like, or days you could not do your work as carefully as usual. If health problems affected your work only a little, choose a low number. Choose a high number if health problems affected your work a great deal.

Consider only how much <u>health problems</u> affected productivity <u>while you were working</u>.

Health problems had no effect on my work	0 1 2 3 4 5 6 7 8 9 10	Health problems completely prevented me from working

CIRCLE A NUMBER

6. During the past seven days, how much did your health problems affect your ability to do your regular daily activities, other than work at a job?

By regular activities, we mean the usual activities you do, such as work around the house, shopping, childcare, exercising, studying, etc. Think about times you were limited in the amount or kind of activities you could do and times you accomplished less than you would like. If health problems affected your activities only a little, choose a low number. Choose a high number if health problems affected your activities a great deal.

Consider only how much <u>health problems</u> affected your ability to do your regular daily activities, other than work at a job.

Health problems had no effect on my daily activities	0 1 2 3 4 5 6 7 8 9 10	Health problems completely prevented me from doing my daily activities

CIRCLE A NUMBER

Appendix 6 – Patient feedback questions

Patients were first asked general questions about telehealth device use and the service.

1. How long have you been using the devices as part of your home care?

2. How often do you use the Mobile device?

3. How often does someone contact you about your home care?

4. Do you need any additional help using the technology?

For each statement, patients were asked to indicate how much they agree/disagree.

5. I am confident in the accuracy of the device readings

6. I had enough training on how to use the telehealth devices

7. I am confident that someone is monitoring the data

8. I think this technology will help the NHS to improve my health care

9. I like to use the internet to look for ways to support my own health

10. I know how to tell the difference between good and bad health advice online

11. My internet or WiFi connection speed is good

The patients were asked to rate their heart failure symptoms on the York scale

12. New York Heart Failure classification
    a. Class I - No symptoms and no limitation in ordinary physical activity, e.g. shortness of breath when walking, climbing stairs etc.
    b. Class II - Mild symptoms (mild shortness of breath and/ or angina) and slight limitation during ordinary activity.
    c. Class III - Marked limitation in activity due to symptoms, even during less-than-ordinary activity, e.g. walking short distances (20—100 m).Comfortable only at rest.
    d. Class IV - Severe limitations. Experiences symptoms even while at rest. Mostly bed bound patients.
    e. No NYHA class listed or unable to determine.

The patients were asked questions relating to their self-efficacy for heart health, which was based on the self-efficacy for chronic disease questionnaire. All questions rated between 1 (not confident at all) to 10 (Totally confident)

13. How confident do you feel that you can keep the fatigue caused by your heart health from interfering with the things you want to do?

14. How confident do you feel that you can keep the physical discomfort or pain of your heart health from interfering with the things you want to do?

15. How confident do you feel that you can keep the emotional distress caused by your heart health from interfering with the things you want to do?

16. How confident do you feel that you can keep any other symptoms or health problems you have from interfering with the things you want to do?

17. How confident do you feel that you can the different tasks and activities needed to manage your heart health so as to reduce your need to see a doctor?

18. How confident do you feel that you can do things other than just taking medication to reduce how much your heart health affects your everyday life.

Appendix 7 – TEC HF cumulative patient recruitment

Month	JUN 21	JUL 21	AUG 21	SEP 21	OCT 21	NOV 21	DEC 21	JAN 22
Carmarthenshire	0	7	36	51	54	61	68	80
Ceredigion	3	12	22	26	28	28	28	30
Pembrokeshire	1	4	10	14	16	20	23	26

Month	FEB 22	MAR 22	APR 22	MAY 22	JUN 22	JUL 22	AUG 22	SEP 22	OCT 22
Carmarthenshire	87	90	96	101	107	114	121	130	133
Ceredigion	31	33	33	33	36	47	53	59	65
Pembrokeshire	27	30	30	31	32	32	32	32	34

Appendix 8 – TEC HF non-cumulative patient recruitment

Month	JUN 21	JUL 21	AUG 21	SEP 21	OCT 21	NOV 21	DEC 21	JAN 22
Carmarthenshire	0	7	29	15	3	7	7	12
Ceredigion	3	9	10	4	2	0	0	2
Pembrokeshire	1	3	6	4	2	4	3	3

Month	FEB 22	MAR 22	APR 22	MAY 22	JUN 22	JUL 22	AUG 22	SEP 22	OCT 22
Carmarthenshire	7	3	6	5	6	7	7	9	3
Ceredigion	1	2	0	0	3	11	6	6	6
Pembrokeshire	1	3	0	1	1	0	0	2	2

Appendix 9 – TEC HF patient discharges

Month	JUN 21	JUL 21	AUG 21	SEP 21	OCT 21	NOV 21	DEC 21	JAN 22
Carmarthenshire	0	0	0	0	0	0	0	0
Ceredigion	0	0	0	0	0	0	0	0
Pembrokeshire	0	0	0	0	0	0	0	0

Month	FEB 22	MAR 22	APR 22	MAY 22	JUN 22	JUL 22	AUG 22	SEP 22	OCT 22
Carmarthenshire	0	0	0	8	4	8	2	8	6
Ceredigion	0	0	0	2	1	2	0	2	14
Pembrokeshire	0	0	0	0	2	3	1	3	5

Appendix 10 – TEC HF active patients

Month	JUN 21	JUL 21	AUG 21	SEP 21	OCT 21	NOV 21	DEC 21	JAN 22
Carmarthenshire	0	0	27	35	48	52	60	69
Ceredigion	0	0	16	23	21	21	20	21
Pembrokeshire	0	0	8	9	12	14	20	23

Month	FEB 22	MAR 22	APR 22	MAY 22	JUN 22	JUL 22	AUG 22	SEP 22	OCT 22
Carmarthenshire	80	81	82	89	91	85	92	94	90
Ceredigion	21	20	19	20	22	29	38	42	31
Pembrokeshire	24	25	25	25	25	22	21	18	15

Appendix 11 – Reading rates by week of service

Month	1	2	3	4	5	6	7	8	9	10
Carmarthenshire	2.4	2.0	1.8	1.7	1.6	1.7	1.5	1.6	1.7	1.6
Ceredigion	2.9	2.4	2.2	2.2	1.9	2.1	2.2	2.0	2.0	1.9
Pembrokeshire	5.0	5.2	5.1	5.5	5.3	5.7	5.3	5.6	5.4	5.3

Month	11	12	13	14	15	16	17	18	19	20
Carmarthenshire	1.7	1.7	1.5	1.6	1.5	1.5	1.4	1.5	1.5	1.4
Ceredigion	2.0	1.9	1.9	1.8	1.7	1.7	1.2	1.4	1.5	1.6
Pembrokeshire	5.2	4.9	4.9	4.6	4.6	4.5	4.4	4.1	4.0	4.2

Appendix 12 – Compliancy by week of service

Month	1	2	3	4	5	6	7	8	9	10
Carmarthenshire	46	55	57	59	61	63	64	64	57	58
Ceredigion	52	55	59	66	59	63	56	70	70	68
Pembrokeshire	46	58	67	67	70	65	63	54	58	53

Month	11	12	13	14	15	16	17	18	19	20
Carmarthenshire	61	53	57	57	54	51	58	52	53	53
Ceredigion	68	65	66	67	59	46	52	50	59	56
Pembrokeshire	58	63	54	51	55	61	60	64	50	54

Appendix 13 – Patient compliancy by month of project

Month	JUN 21	JUL 21	AUG 21	SEP 21	OCT 21	NOV 21	DEC 21	JAN 22
Carmarthenshire	0.0	0.0	47.8	56.2	63.9	64.3	57.5	58.3
Ceredigion	0.0	0.0	66.9	59.4	55.0	55.6	56.1	64.8
Pembrokeshire	0.0	0.0	45.3	50.4	67.0	70.1	71.4	68.0

Month	FEB 22	MAR 22	APR 22	MAY 22	JUN 22	JUL 22	AUG 22	SEP 22	OCT 22
Carmarthenshire	57.3	54.5	45.7	44.5	41.1	49.0	51.3	52.7	61.4
Ceredigion	57.6	51.8	43.0	45.7	32.9	65.6	63.2	62.3	68.0
Pembrokeshire	55.4	55.0	52.3	58.1	47.2	47.5	62.7	56.3	65.5

Appendix 14 – Hospital admissions data for all counties

		May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22
Carmarthen	Non-TEC	58	78	38	66	44	46	27	45	50	42	31	36	40	13	11	10	16	9
	Before/After TEC	4	10	6	4	1	2	2	2	6	6	3	1	7	1	1	0	0	0
	During TEC	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0
	Active TEC patients	0	0	0	27	35	48	52	60	69	80	81	82	89	91	85	92	94	90
	TEC Patient recruitment	0	0	7	36	51	54	61	68	80	87	90	96	101	107	114	121	130	133
Ceredigion	Non-TEC	19	22	20	10	9	13	17	16	25	22	31	20	24	7	9	5	7	2
	Before/After TEC	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	During TEC	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	Active TEC patients	0	0	0	16	23	21	21	20	21	21	20	19	20	22	29	38	42	31
	TEC Patient recruitment	0	3	12	22	26	28	28	28	30	31	33	33	33	36	47	53	59	65
Pembroke	Non-TEC	42	23	24	25	21	35	33	33	24	31	32	37	25	13	14	16	20	6
	Before/After TEC	0	1	1	9	4	2	1	0	0	0	0	0	0	0	0	0	0	0
	During TEC	0	0	0	2	1	0	0	0	0	0	1	1	0	0	0	0	0	0
	Active TEC patients	0	0	0	8	9	12	14	20	23	24	25	25	25	25	22	21	18	15
	TEC Patient recruitment	0	1	4	10	14	16	20	23	26	27	30	30	31	32	32	32	32	34
Totals (3 counties)	Non-TEC	119	123	82	101	74	94	77	94	99	95	94	93	89	33	34	31	43	17
	Before/After TEC	4	13	7	13	5	4	3	2	6	6	3	1	7	1	2	0	0	0
	During TEC	0	0	0	2	1	3	2	0	0	0	1	1	1	0	0	0	0	0
	Active TEC patients	0	0	0	51	67	81	87	100	113	125	126	126	134	138	136	151	154	136
	TEC Patient recruitment	0	4	23	68	91	98	109	119	136	145	153	159	165	175	193	206	221	232

Appendix 15 – Outpatient appointments data for all counties

		May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22
Carmarthen	Non-TEC	306	360	291	263	256	270	269	153	215	173	155	109	170	98	205	250	344	267
	Before/After TEC	8	15	17	29	14	7	8	15	17	7	8	4	7	6	13	10	14	5
	During TEC	0	0	0	6	25	37	29	22	28	17	29	15	29	30	28	29	50	29
	Active TEC patients	0	0	0	27	35	48	52	60	69	80	81	82	89	91	85	92	94	90
	TEC Patient recruitment	0	0	7	36	51	54	61	68	80	87	90	96	101	107	114	121	130	133
Ceredigion	Non-TEC	42	52	49	46	48	43	35	30	29	32	34	20	39	31	154	267	234	194
	Before/After TEC	5	6	5	0	3	1	0	1	0	0	1	2	3	0	11	7	10	20
	During TEC	0	0	0	3	1	1	1	1	0	1	1	1	0	0	19	44	20	18
	Active TEC patients	0	0	0	16	23	21	21	20	21	21	20	19	20	22	29	38	42	31
	TEC Patient recruitment	0	3	12	22	26	28	28	28	30	31	33	33	33	36	47	53	59	65
Pembroke	Non-TEC	0	0	0	1	0	0	0	0	3	11	17	2	20	11	104	140	153	78
	Before/After TEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0
	During TEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	11	3	2
	Active TEC patients	0	0	0	8	9	12	14	20	23	24	25	25	25	25	22	21	18	15
	TEC Patient recruitment	0	1	4	10	14	16	20	23	26	27	30	30	31	32	32	32	32	34
Totals (3 counties)	Non-TEC	348	412	340	310	304	313	304	183	247	216	206	131	229	140	463	657	731	539
	Before/After TEC	13	21	22	29	17	8	8	16	17	7	9	6	10	6	24	19	26	25
	During TEC	0	0	0	9	26	38	30	23	28	18	30	16	29	30	54	84	73	49
	Active TEC patients	0	0	0	51	67	81	87	100	113	125	126	126	134	138	136	151	154	136
	TEC Patient recruitment	0	4	23	68	91	98	109	119	136	145	153	159	165	175	193	206	221	232

Appendix 16 – TEC only outpatient appointments

Month added to TEC	Sum prior to TEC	6 month prior	5 month prior	4 month prior	3 month prior	2 month prior	1 month prior	1 month on TEC	2 month on TEC	3 month on TEC	4 month on TEC	5 month on TEC	6 month on TEC	Sum months on TEC
August,2021	0								1	1	1		1	4
August,2021	7	2	1		2	1	1			1	1	1	1	4
August,2021	2	1					1		1	1	1			3
August,2021	4	1	1	1			1		1					1
August,2021	0								1	1	1		1	4
August,2021	4	1		1		1	1	1	1	1				3
August,2021	0							1	1		1			3
August,2021	0													0
August,2021	0							1	1	1	1			4
August,2021	3	1	1			1		1	1					2
August,2021	6	1	1		1	1	2	1	1	1			1	4
August,2021	0							1	1		1		1	4
August,2021	4	1	1		1		1	2						2
August,2021	2		1				1		1		1			2
August,2021	0							1		1	1		1	4
December,2021	1						1	1	1	1	2	1	1	7
December,2021	0													0
November,2021	2					1	1			1				1
November,2021	2						2	1	1	1	1	1		5
November,2021	0													0
November,2021	1						1	2			1	1	1	5
October,2021	4	1		1		1	1	1	1	1			1	4
October,2021	3	1		1			1		1		1			2
October,2021	1						1				1			1
October,2021	3	1	1				1	1				1		2
October,2021	2		1				1	1		1				2
September,2021	1					1		1						1
September,2021	1				1					1		1	1	3
September,2021	0								1					1
August,2021	5	1	1	1		1	1							0
August,2021	3	1		1	1			1						1
August,2021	4	3	1											0
August,2021	2		1	1										0
August,2021	0													0
August,2021	0													0
July,2021	0													0
October,2021	4	2	1			1								0
October,2021	0													0
September,2021	0													0
September,2021	1	1												0
September,2021	0													0
August,2021	0													0
August,2021	2	1	1											0
August,2021	0													0
August,2021	0													0
December,2021	0													0
December,2021	0													0
December,2021	0													0
December,2021	0													0
July,2021	0													0
July,2021	0													0
July,2021	0													0
November,2021	0													0
November,2021	0													0
November,2021	0													0
November,2021	0													0
October,2021	0													0
October,2021	0													0
October,2021	0													0
September,2021	0													0
September,2021	0													0
Totals	74	20	12	8	6	9	19	17	16	15	15	6	10	79
TEC Month		-6	-5	-4	-3	-2	-1	1	2	3	4	5	6	

Appendix 17 – TEC only hospital admissions (no NEW)

Month added to TEC	Hosp 6 month prior	Hosp 5 month prior	Hosp 4 month prior	Hosp 3 month prior	Hosp 2 month prior	Hosp 1 month prior	Hosp 1 month post	Hosp 2 month post	Hosp 3 month post	Hosp 4 month post	Hosp 5 month post	Hosp 6 month post
August,2021												
August,2021												
August,2021												
August,2021												
October,2021												
August,2021							1(0)					
August,2021												
August,2021												
November,2021												
October,2021												
August,2021				2(1,2)					1(0)			
December,2021												
November,2021												
October,2021												
August,2021												
December,2021												
August,2021												
September,2021												
September,2021	1(3)											
November,2021					1(3)							
August,2021												
August,2021												
September,2021												
August,2021												
November,2021												
August,2021						1(6)						
September,2021												
July,2021												
August,2021												
September,2021												
August,2021												
September,2021		1(6)										
August,2021												
August,2021												
October,2021												
August,2021												
August,2021												
December,2021												
November,2021												
September,2021												
July,2021												
December,2021												
December,2021												
October,2021												
October,2021					6(0,0,0,0,0	2(0,0)						
October,2021				2(0,0)								
August,2021												
December,2021												
July,2021												
November,2021			2(4,21)									
August,2021												
July,2021												
November,2021												
November,2021												
September,2021				3(0,6,8)								
TEC Month	-6	-5	-4	-3	-2	-1	1	2	3	4	5	6
Number of admissions	1	1	2	7	7	3	1	0	1	0	0	0
Median bed days	3	6	12.5	1	0	0	0	0	0	0	0	0

Total number of patients included	55	Total number of patients included	55
Before number of admissions total	21	After number of admissions total	2
Before number of bed days total	62	After number of bed days total	0
Before number of bed days (median)	62	After number of bed days (median)	0
Before patients with >= 1 admission	12	After patients with >= 1 admission	2

Appendix 18 – Pairs plots of TEC factors

# Appendix 19 – Linear correlation coefficients with plots
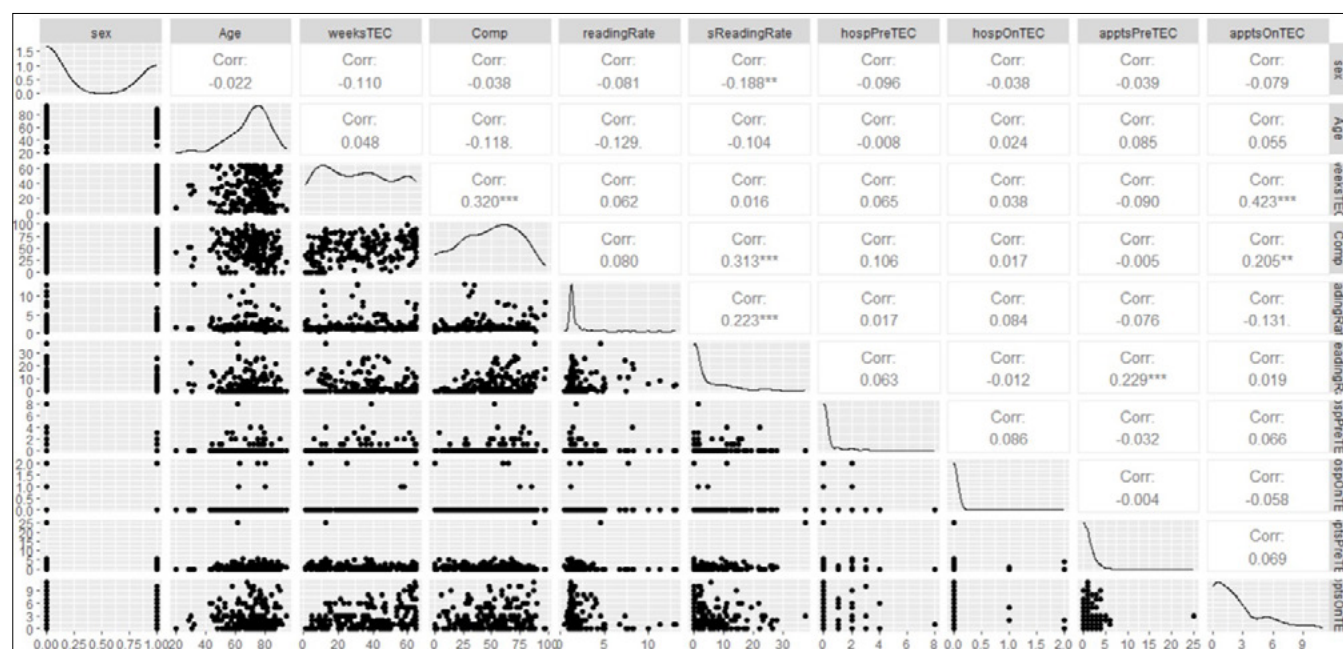
Appendix 20 – Histogram of variances and residual vs fitted model diagrams

Histogram of residuals
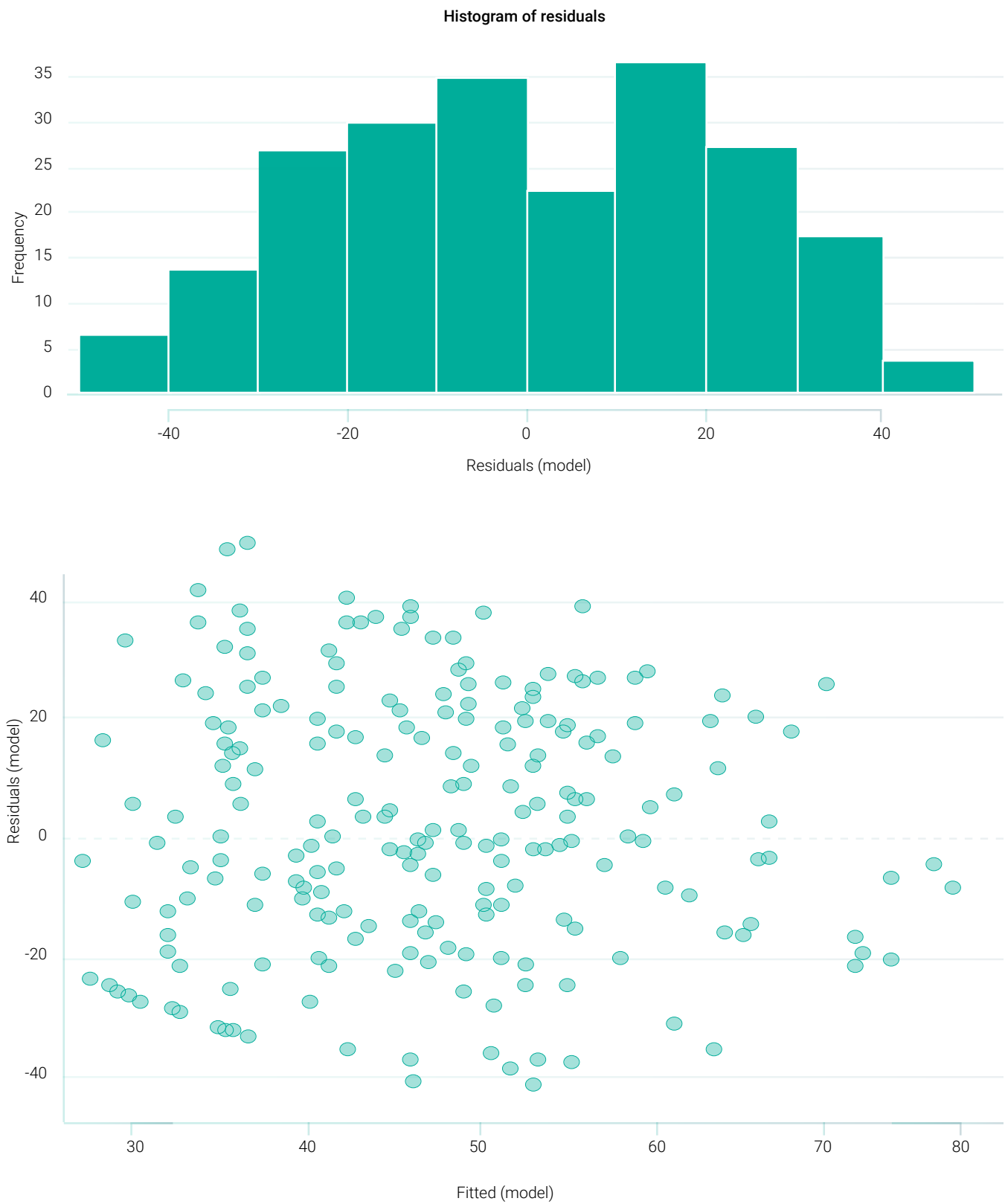
Appendix 21 – PROMS summary and abbreviations

Proms type	Question	Abbreviated
Non-validated / Other	Age of patient (years)	AGE
	Weight of patient (kg)	Weight
	What level of activity/exercise did you mainly take last week?	ActiveLevel
	Roughly how much times did you spend being active/exercising last week?	ActiveTime
	TEC device compliancy	COMP
	Number of weeks enrolled onto the TEC HF service	WEEKS
	Average number of reading requests received on myMobile each week	ReadRATE
	Number of severe readings / Total number of reading requests	SevereRATE
	Number of outpatient appointments / Number of weeks using TEC HF service	OPApptRate
KCCQ-12	KCCQ-12 Summary score	KCCQ12S
	Physical limitation score	KCCPL
	Symptom frequency score	KCCSF
	Quality of life score	KCCQL
	Social limitation score	KCCSL
	Limitations with showing or having a bath	Shower
	Limitations with Walking 100 yards on level ground	Walking
	Limitations with jogging or hurrying (as if to catch a bus)	Jogging
	Over the past 2 weeks, how many times have you had swelling in your feet, ankles or	Swelling
	Over the past 2 weeks, on average, how many times has fatigue limited your ability to	Fatigue
	Over the past 2 weeks, on average, how many times has shortness of breath limited	Breath
	Over the past 2 weeks, on average, how many times have you been forced to sleep	SleepChair
	Over the past 2 weeks, how much has your HEART FAILURE limited your enjoyment of	EnjoyLife
	If you had to spend the rest of your life with your HEART FAILURE the way it is right	Feel
	How has HF affected - Hobbies, recreational activities	Hobby
	How has HF affected - Working or doing household chores	Chores
	How has HF affected - Visiting family or friends	VisitingFs
PHQ-2	Calculated PHQ2 score	PHQ2
	Little interest or pleasure in doing things?	Linterest
	Feeling down, depressed or hopeless?	FeelDown
PROMIS 4a	Calculated PROMIS 4a score	PROMIS
	Are you able to do chores such as vacuuming or yard work?	ChoresVY
	Are you able to go up and down stairs at a normal pace?	UpStairs
	Are you able to go for a walk of at least 15 minutes?	Walk15
	Are you able to run errands and shop?	ErrandS
EQ-5D-5L	EQ-5D-5L Index score (calculated)	EQIndex
	Mobility	Mobility
	Self-care	SelfCare
	Usual activities	UsualAct
	Pain/discomfort	Pain
	Anxiety/depression	Anxiety
	Self score for how you are feeling today	HealthToday
WPAI	Are you currently in paid employment?	N/A
	During the past seven days, how many hours did you miss from work because of your	N/A
	During the past seven days, how many hours did you actually work?	N/A
	During the past seven days, how much did your health problems affect your	N/A
	During the past seven days, how much did your health problems affect your ability to	DailyAct

Appendix 22 – PROMS TEC/No-TEC

PROM	Abbreviation	Wilcox Test statistic	p-value	TEC Median (Mean)	NonTEC Median (Mean)
Non-validated / Other	Weight	42548	0.05508		
	ActiveLevel	31598	0.001353	2 (1.75)	2 (1.95)
	ActiveTime	34879	0.1508		
KCCQ-12	KCCQ12S	34950	0.1671		
	KCCPL	33739	0.08335		
	KCCSF	35600	0.2695		
	KCCQL	35672	0.2818		
	KCCSL	33587	0.0488	37.50	50.00
	Shower	35326	0.2082		
	Walking	32677	0.01648	3 (2.84)	3 (3.22)
	Jogging	37462	0.7495		
	Swelling	37426	0.7168		
	Fatigue	35420	0.2338		
	Breath	35571	0.2584		
	SleepChair	39484	0.4957		
	EnjoyLife	35704	0.2823		
	Feel	35985	0.3395		
	Hobby	36577	0.4884		
	Chores	34072	0.0753		
	VisitingFs	33341	0.03462	3 (2.79)	3 (3.16)
PHQ-2	PHQ2	41970	0.09646		
	Linterest	42770	0.0406	1 (1.34)	1 (1.10)
	FeelDown	41238	0.1695		
PROMIS 4a	PROMIS	31293	0.003163	11.00	13.00
	ChoresVY	32523	0.01401	3 (2.83)	3 (3.17)
	UpStairs	32649	0.01629	3 (2.87)	3 (3.21)
	Walk15	30885	0.001495	3 (2.70)	3 (3.19)
	ErrandS	31834	0.005616	3 (2.88)	3.25 (3.31)
EQ-5D-5L	EQIndex	32167	0.01004	0.68	0.74
	Mobility	43902	0.0123	3 (2.72)	2 (2.41)
	SelfCare	41568	0.1127		
	UsualAct	43538	0.01958	3.00	2.50
	Pain	42294	0.06847		
	Anxiety	42418	0.05932		
	HealthToday	33247	0.03945	50.00	60.00
WPAI	DailyAct	42059	0.09559		

Appendix 23 – TEC patient medians (correlation results)

Denotes significance to p<0.05	Denotes significance p<0.01

Pearson's Correlation for TEC factors, activity questions from VBHC and age and weight of patient

	Age	Weight	ActiveLevel	ActiveTime	COMP
Age	1.00	-0.26	-0.08	0.03	-0.27
Weight	-0.26	1.00	-0.44	-0.23	0.00
ActiveLevel	-0.08	-0.44	1.00	0.62	0.34
ActiveTime	0.03	-0.23	0.62	1.00	0.18
Comp	-0.27	0.00	0.34	0.18	1.00
Weeks	0.01	0.17	0.01	0.01	0.27
ReadRATE	-0.10	-0.06	0.02	-0.05	0.05
SevereRATE	-0.30	0.11	-0.11	-0.08	0.34
OPApptRate	0.16	-0.22	0.15	0.03	0.02

Pearson's Correlation for TEC factors against KCCQ-12

	COMP	WEEKS	ReadRATE	SevereRate	OPApptRate
KCCQ12S	0.04	0.10	0.02	-0.14	0.11
KCCPL	0.20	-0.07	0.16	0.02	0.14
KCCSF	0.18	0.20	0.03	-0.17	0.06
KCCQL	-0.16	0.15	-0.04	-0.20	0.10
KCCSL	0.06	0.02	0.02	-0.10	0.08
Shower	0.16	-0.01	0.18	0.01	0.06
Walking	0.21	-0.07	0.16	0.00	0.15
Jogging	-0.01	-0.13	0.20	-0.01	0.01
Swelling	0.20	0.16	0.07	-0.31	-0.04
Fatigue	0.07	0.14	0.04	-0.15	0.09
Breath	0.09	0.15	-0.18	0.01	0.29
SleepChair	0.17	0.22	0.06	-0.22	-0.22
EnjoyLife	-0.13	0.11	-0.04	-0.12	0.10
Feel	-0.11	0.16	-0.04	-0.24	0.09
Hobby	0.03	-0.01	0.04	-0.08	0.03
Chores	0.21	-0.02	0.02	-0.04	0.21
VisitingFs	0.12	0.10	0.12	-0.03	-0.22

Pearson's Correlation for TEC factors against PHQ-2, PROMIS 4a, EQ-5D-5L and WPAI

	COMP	WEEKS	ReadRATE	SevereRate	OPApptRate
PHQ2	-0.01	-0.16	-0.18	0.16	-0.09
Linterest	-0.07	-0.11	-0.19	0.14	-0.05
FeelDown	0.04	-0.20	-0.14	0.16	-0.11
PROMIS	0.09	0.00	0.21	-0.09	-0.02
ChoresVY	0.17	-0.02	0.13	-0.09	0.11
UpStairs	0.11	0.03	0.15	-0.03	-0.09
Walk15	0.05	-0.02	0.19	-0.14	0.04
ErrandS	0.08	0.00	0.25	-0.11	-0.14
EQIndex	0.22	0.04	0.18	0.01	0.15
Mobility	-0.25	0.09	-0.23	-0.04	-0.16
SelfCare	-0.14	0.04	-0.16	0.06	-0.09
UsualAct	-0.12	0.02	-0.03	0.03	-0.17
Pain	-0.20	0.02	-0.16	-0.01	-0.15
Anxiety	-0.08	-0.29	-0.12	0.10	-0.04
HealthToday	-0.02	0.05	0.12	-0.19	0.16
DailyAct	-0.08	-0.04	-0.11	0.14	-0.04

Appendix 24 – Patient feedback demographics

Pseudo ID	Age	Sex	Treatment Team	How long have you been using TEC?	How often do you use the MyMobile Device?	How often are you contacted about the telehealth service	Do you need help using the technology?	Who helps you?
1	81	male	Carmarthenshire	3 to 6 months	Once a week	Less than once per month	no	
2	75	male	Ceredigion	Less than 1 month	Once a week	Less than once per month	no	
3	51	male	Carmarthenshire	1 to 3 months	< Once per month	Less than once per month	no	
4	71	male	Carmarthenshire	More than 12 months	Once a week	Less than once per month	no	
5	64	male	Pembrokeshire	6 to 9 months	Every day	Less than once per month	no	
6	71	female	Carmarthenshire	6 to 9 months	Once a week	Less than once per month	no	
7	67	male	Carmarthenshire	3 to 6 months	Once a month	Less than once per month	no	
8	70	male	Carmarthenshire	More than 12 months	Once a week	Less than once per month	no	
9	73	male	Carmarthenshire	6 to 9 months	Once a week	Once a month	no	
10	71	male	Carmarthenshire	6 to 9 months	Once a week	Less than once per month	no	
11	66	female	Pembrokeshire	9 to 12 months	Several times a week	Less than once per month	no	
12	64	female	Pembrokeshire	3 to 6 months	Several times a week	Once a month	no	
13	64	female	Carmarthenshire	Less than 1 month	Once a month	Less than once per month	no	
14	73	male	Carmarthenshire	9 to 12 months	Once a week	Once a month	no	
15	70	male	Carmarthenshire	3 to 6 months	Once a week	Less than once per month	no	
16	68	female	Carmarthenshire	1 to 3 months	Once a week	Less than once per month	no	
17	67	male	Ceredigion	1 to 3 months	Once a week	Once a month	no	
18	66	male	Ceredigion	1 to 3 months	Once a week	Once a month	no	
19	69	male	Pembrokeshire	More than 12 months	Several times a day	Less than once per month	no	
20	67	male	Pembrokeshire	More than 12 months	Every day	Less than once per month	no	
21	79	female	Ceredigion	More than 12 months	Once a week	Less than once per month	no	
22	69	male	Carmarthenshire	More than 12 months	Once a week	Less than once per month	no	
23	58	female	Ceredigion	3 to 6 months	Once a week	Less than once per month	no	
24	58	female	Carmarthenshire	More than 12 months	Once a week	Once a month	no	
25	62	male	Carmarthenshire	9 to 12 months	Once a week	Once a month	no	
26	58	male	Pembrokeshire	1 to 3 months	Once a month	Once a month	no	
27	44	female	Pembrokeshire	More than 12 months	Once a week	Once a month	no	
28	54	female	Carmarthenshire	Less than 1 month	Once a week	Less than once per month	no	
29	82	female	Ceredigion	9 to 12 months	Once a week	Once a month	no	
30	84	male	Ceredigion	Less than 1 month	Once a week	Less than once per month	no	
31	95	male	Carmarthenshire	6 to 9 months	Once a week	Less than once per month	no	
32	86	male	Carmarthenshire	6 to 9 months	Once a week	Less than once per month	no	
33	84	male	Carmarthenshire	More than 12 months	Several times a month	Less than once per month	yes	Family member
34	76	male	Ceredigion	6 to 9 months	Once a week	Once a month	no	
35	80	male	Ceredigion	More than 12 months	Once a week	Less than once per month	no	
36	79	female	Carmarthenshire	More than 12 months	Once a week	Once a month	no	
37	77	male	Ceredigion	3 to 6 months	Once a week	Once a month	no	
38	48	female	Ceredigion	6 to 9 months	Once a week	Less than once per month	no	
39	58	female	Carmarthenshire	6 to 9 months	Once a week	Less than once per month	no	
40	78	male	Pembrokeshire	9 to 12 months	Once a week	Once a month	no	
41	73	male	Pembrokeshire	9 to 12 months	Several times a week	Less than once per month	no	
42	44	male	Carmarthenshire	1 to 3 months	Every day	Less than once per month	no	

Appendix 25 – Patient feedback on TEC

Pseudo ID	I am confident in the accuracy of the device readings	I had enough training on how to use the telehealth devices	I am confident that someone is monitoring the data	I think this technology will help the NHS to improve my health care	I like to use the internet to look for ways to support my own health	I know how to tell the difference between good and bad health advice online	My internet or WiFi connection speed is good
1	Agree	Agree	Agree	Strongly agree	Agree	Agree	Agree
2	Strongly agree	Agree	Agree	Agree	Agree	Do not use	Strongly agree
3	Agree	Agree	Strongly agree	Agree	Agree	Agree	neither
4	Agree	Strongly agree	Agree	Strongly agree	Agree	Agree	Agree
5	Disagree	Disagree	Agree	Agree	Strongly agree	Agree	Strongly agree
6	neither	Agree	neither	neither	neither	Agree	Agree
7	neither	neither	Agree	Agree	Strongly disagree	Agree	Agree
8	Agree	Agree	Agree	Agree	Agree	Agree	Agree
9	Agree	Strongly agree	Agree	Agree	Agree	Agree	Agree
10	Strongly agree	Strongly agree	Agree	Strongly agree	Agree	Agree	Disagree
11	Agree	Agree	Agree	Agree	Agree	Agree	Agree
12	Strongly agree	Strongly agree	Agree	Agree	Agree	Agree	Agree
13	Agree	Agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Agree
14	Agree	Agree	Agree	Agree	Agree	Agree	Agree
15	Agree	Agree	Agree	Agree	Agree	Agree	Agree
16	Agree	Agree	Agree	Agree	Agree	Agree	Agree
17	Agree	Agree	Agree	Strongly agree	Agree	Agree	Agree
18	Strongly agree	Strongly agree	Agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree
19	neither	Agree	Agree	Agree	neither	Agree	Agree
20	Agree	Strongly agree	Disagree	neither	Strongly agree	Strongly agree	Strongly agree
21	Strongly disagree	Agree	Agree	Agree	Disagree	Agree	Strongly disagree
22	Agree	Agree	Agree	Agree	Agree	neither	Agree
23	Agree	Agree	Agree	Agree	Agree	Agree	Agree
24	Agree	Agree	Agree	Agree	Agree	Agree	Agree
25	Strongly agree	Agree	Agree	Agree	Agree	Agree	Agree
26	Agree	Agree	Agree	Agree	Agree	Agree	Agree
27	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Agree	Strongly agree	Strongly agree
28	Agree	Agree	Agree	Agree	Agree	Agree	Agree
29	Agree	Agree	Strongly agree	Strongly agree	Agree	Agree	Agree
30	Agree	Agree	Agree	Agree	Agree	Agree	Disagree
31	Agree	Agree	Agree	Agree	Agree	Agree	neither
32	Agree	Strongly agree	Agree	Agree	Agree	Agree	Agree
33	Strongly agree	neither	neither	neither	Strongly disagree	Agree	neither
34	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Agree	Strongly agree
35	Strongly agree	Agree	Agree	Agree	Disagree	Agree	neither
36	Agree	Agree	Agree	Agree	Do not use	Do not use	Do not use
37	Strongly agree	Agree	Strongly agree	Strongly agree	Strongly agree	Agree	Agree
38	Agree	Agree	Strongly agree	Strongly agree	Agree	Strongly agree	Strongly agree
39	Agree	Agree	Disagree	Disagree	Disagree	Agree	Agree
40	Agree	Agree	Agree	Agree	Agree	Agree	Agree
41	Agree	neither	Strongly agree	Agree	Disagree	neither	Agree
42	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree	Strongly agree

Appendix 26 – Patient feedback on management of their health

Pseudo ID	New York HF classification	New York HF Class	Fatigue management	Pain or discomfort management	Emotional distress management	Other symptoms management	Carrying out tasks and activities to reduce health care need	Confidence with anything else other than medication
1	None	1	9	9	9	9	9	8
2	Moderate	3	8	8	8	8	8	8
3	Moderate	3	4	5	7	5	5	3
4	Mild	2	4	5	7	5	6	1
5	Severe	4	2	2	1	1	2	2
6	Mild	2	9	9	9	9	9	9
7	Severe	4	6	5	6	4	4	3
8	Mild	2	7	8	8	7	7	8
9	None	1	9	10	10	10	10	10
10	None	1	7	8	8	8	8	8
11	Mild	2	9	9	9	9	9	9
12	Moderate	3	8	8	8	9	8	8
13	None	1	4	4	3	3	3	3
14	Mild	2	1	Left blank				
15	Moderate	3	2	2	3	2	5	2
16	Mild	2	7	8	8	7	8	8
17	Mild	2	8	9	10	8	8	8
18	None	1	10	10	10	10	10	10
19	Moderate	3	4	5	10	5	5	5
20	Severe	4	2	2	3	2	3	3
21	Moderate	3	1	1	4	8	3	2
22	Mild	2	7	7	8	5	8	7
23	Mild	2	5	5	5	5	5	5
24	Mild	2	6	4	4	4	4	4
25	None	1	8	8	8	8	4	4
26	Severe	4	1	1	1	1	1	3
27	Moderate	3	4	4	2	3	5	6
28	Severe	4	1	1	1	2	1	1
29	Mild	2	7	10	10	7	10	6
30	Mild	2	7	7	9	9	9	9
31	Moderate	3	5	5	4	4	5	4
32	Mild	2	8	8	8	8	7	8
33	Mild	2	5	6	7	4	5	4
34	Severe	4	5	5	4	3	4	6
35	Mild	2	6	8	9	8	8	7
36	Mild	2	1	1	1	1	5	1
37	Mild	2	7	8	7	5	9	8
38	None	1	7	7	8	7	9	8
39	Mild	2	7	8	8	7	8	8
40	Mild	2	5	5	5	5	5	5
41	Mild	2	8	7	7	7	7	7
42	Mild	2	5	5	5	5	10	6

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