

Evaluation of past and present implementation of Telemonitoring NI: Executive Summary

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Evidence Brief

Why did we start?

The Centre for Connected Health and Social Care (CCHSC) in Northern Ireland launched the Telemonitoring NI project in 2011 in the five Health and Social Care Trusts. It includes telehealth and telecare. Telehealth uses sensors and devices to monitor remotely health-related parameters in patients, allowing interventions to be introduced in a timely manner. Telecare involves the use of sensors in patients' homes to detect events. Outputs from the sensors are monitored remotely so that assistance can be provided by telephone or via the emergency services, with the aim of promoting early intervention and, thereby, maintaining patient wellbeing. This project evaluates Telemonitoring NI.

What did we do?

We used a mixed methods approach for the telehealth evaluation, focusing on heart failure, COPD, hypertension and diabetes; with a supplementary analysis for stroke. We did descriptive analyses of uptake, quantitative analyses of the service's effects on health outcomes and qualitative analyses of the views of patients, carers and practitioners. A purely quantitative approach was used in the evaluation of telecare, to review uptake and examine use of health services.

What answer did we get?

There has been a steady stream of telehealth installations since its introduction and engagement was good across all Trusts. The most striking finding of the quantitative evaluation was a higher mortality rate (33.3%) within the quasi-control 'Never installed' group compared to the 'Installed' group (13.9%). Although tempting to infer that the results are indicative of the telehealth alerts facilitating the early implementation of life saving interventions, at least some of these patients probably did not have equipment installed because they had become morbidly unwell. In general terms, hospitalisations, length of hospital stay, outpatient clinic attendance, and costs of healthcare provision did not differ between the 'Never installed' group and those receiving telemonitoring. In the qualitative study, support for the telehealth service was overwhelmingly positive, particularly from patients (and their carers). In the telecare study, the high number of 'calls' from patients who had the equipment installed indicate that these were high dependence patients and it seems likely that appropriate actions by the telecare team led to the prevention of negative health outcomes for them.

What should we do now?

Several recommendations arise relating to, for example, better engagement with other health care professionals (including GPs and community pharmacists), evolving the intervention within a complex intervention framework, collecting data that could facilitate future research and initiating a prospective, robust evaluation (such as a randomised trial) of future telehealth or telecare services in Northern Ireland.

Background

Telehealth is the use of a variety of sensors and devices to monitor remotely health-related parameters in patients. This usually involves telephone or internet-based technology, to allow care providers to monitor information on patient vital signs. Deviation of the latter from the patient's norm alerts the healthcare provider to the possible need for intervention. Since the monitoring becomes routine and patients are empowered to be more active in their own self-care, interventions can be introduced in a timely manner, with the intent of preventing, for example, the need for the patient to seek emergency hospital care. Telecare uses a different approach to telehealth and serves a different purpose. It involves the use of sensors in patients' homes to detect events, such as smoke in the kitchen, front door left open or that the patient has had a fall. Outputs from the sensors are monitored remotely by the telecare team who can provide assistance, as required, by telephone or via the emergency services, with the aim of promoting early intervention and, thereby, maintaining patient wellbeing.

Recent telemonitoring research studies have covered a range of chronic health conditions, including hypertension (Parati *et al.*, 2009), heart failure (Inglis *et al.*, 2010; Dendale *et al.*, 2012, Odeh 2105 *et al.*, Steventon *et al.* 2016), respiratory conditions (asthma, COPD and cystic fibrosis; Cleland *et al.*, 2007; Jarad and Sund, 2011; Ryan *et al.*, 2012, Odeh *et al.* 2015, Rixon *et al.* 2015, Steventon *et al.* 2016) and diabetes (Cho *et al.*, 2009; Steventon *et al.* 2014, Steventon *et al.* 2016). Some very positive outcomes have been reported, such as significant decreases in mortality and hospitalisations in a heart failure group (Dendale *et al.*, 2012), but the positive results in that study of 160 patients were not reflected in a larger study of 1600 patients (Chaudhry *et al.*, 2010). The largest randomised trial to date in the UK is the Whole System Demonstrator project, which involved more than 6000 patients. Again, the results have been mixed, with a decreased incidence of hospital admissions and mortality in the 12 month follow-up period in the telemonitoring group (Steventon *et al.*, 2012); quality of life and psychological outcomes were not improved (Cartwright *et al.*, 2013) and cost per quality adjusted life year (QALY) was similar in each group due to the higher total costs of the telemonitoring intervention (Henderson *et al.*, 2013). Alongside the objective data, subjective views of patients on telemonitoring have generally been positive, while healthcare professionals are more cautious in their acceptance of the approach (Fairbrother *et al.*, 2013).

The Centre for Connected Health and Social Care (CCHSC) in Northern Ireland launched the Telemonitoring NI project in 2011. This continues to be implemented by all five Health and Social Care (HSC) Trusts, across a range of chronic conditions. The present project relates to an evaluation of the impact of this programme, which was implemented without a formal evaluation plan, rather than as a randomised trial, controlled before and after study or an interrupted time series. Telemonitoring NI encompasses both telehealth and telecare programmes, which are delivered by the TF3 consortium (Tunstall, Fold and S3) in collaboration with the five HSC Trusts (i.e. Belfast, Northern, South Eastern, Southern and Western Health and Social Care Trusts: BHSCT, NHSCT, SEHSCT, SHSCT and WHSCT). Telehealth is provided to patients with a range of chronic conditions, e.g. diabetes and COPD, and involves the use, by the patient, of home monitoring devices, with the results of such monitoring

being made available via telephone / internet connection to a triage team and/or other healthcare providers. The telehealth programme is divided into two streams: (i) Triage and (ii) Track & Trend. The former involves daily monitoring, with alerts being sent directly to a triage team (nurses) who decide on what action is necessary. Track & Trend monitoring, on the other hand, may be less frequent than daily. The system does not send alerts to the triage team, but instead the profiles of patient data, such as blood sugar levels over time, are viewed directly by the healthcare professional who is responsible for the patient's care, and who can review trends within the data and make interventions as appropriate.

This evaluation of telehealth involved analysis of patient data held by the service provider (TF3) and the HSC Trusts, together with data collected from patients and their carers and healthcare providers. The evaluation of telecare used patient data held by TF3 and healthcare usage data. It did not involve any focus groups or interviews with patients, carers or healthcare professionals or the completion of any questionnaires by patients and unlike the telehealth evaluations, there were no control (service recommended but not installed) data.

Aims and objectives

The results of this research project overall will inform the process of continuous quality improvement of these remote surveillance services and inform future developments of the services. The primary aims were: (a) to construct a descriptive summary of the ongoing telehealth NI programme, (b) to evaluate the impact of the telehealth programme on healthcare resource usage (for example, hospitalisations) and patient self-efficacy / ability for self-care, (c) to determine the views of patients, their carers and healthcare professionals on the telehealth service, and (d) to carry out a preliminary evaluation of the telecare provision across NI. The specific objectives of the telehealth evaluation were:

1. Using routine administrative data collected by the provider (TF3) as part of the service provision, together with datasets held in the Business Services Organisation (BSO), provide a descriptive summary of the services delivered from the time of initiation of the service to the present time.
2. Through the conduct of retrospective and prospective surveys of patients who have received or are currently receiving the telehealth service, evaluate its impact on health-related quality of life and self-care (self-efficacy) for specific target conditions, i.e. heart failure, COPD, hypertension and diabetes.
3. Using data held by TF3 and the HSC Trusts, compare healthcare utilisation (hospitalisations, emergency care) by patients pre- and post-use of the service and by patients who received the service versus those who were referred to receive the service but for some reason the equipment was not installed in their home (e.g. patient declined the service or were found to be unsuitable).
4. Conduct qualitative research (focus group discussions) to gather information on the views and experiences of telehealth service users. Interviews with a number of stroke patients and their carers formed an additional group within this objective.
5. Conduct interviews with a range of healthcare professionals who are directly involved in telehealth provision (or who have the potential to be involved in the future) to gather information on their views to this new approach to community based care.

6. Conduct a health economic analysis on the telehealth programme.

The specific objective of the telecare evaluation was:

7. Using data held by TF3 and the HSC Trusts on the Telecare NI programme, provide a descriptive summary of the services.

Methods

A mixed methods approach was used for the telehealth evaluation, with a focus on four clinical conditions: heart failure, COPD, hypertension and diabetes. A supplementary analysis was also done for stroke. In order to account for differing levels of exposure to telehealth, we divided patients into five groups: (i) Never installed - patient was referred but equipment was not installed, (ii) Successful - patient joined service and was subsequently discharged with outcome recorded as achieved, (iii) Not successful - patient joined service, but was discharged with outcome recorded as unsuccessful, e.g. non-compliance with service, (iv) Discharged with no reason for discharge given and finally (v) Ongoing - patient joined service and continues to receive it. In the absence of a randomised control group, or some other prospectively collected comparable group, the 'Never installed' group acted as a quasi-control group in all datasets and groups (ii) to (v) were combined to create an 'Installed' group.

The series of studies undertaken to evaluate the telehealth programme include descriptive analyses of the uptake of the service, quantitative analyses of its effects on health-related outcomes and qualitative analyses of the views of patients, patient carers and practitioners. Routine data collected by the provider (TF3) as part of the service provision, together with datasets held in the Business Services Organisation Information Technology Services (BSO ITS) were used to provide a descriptive summary and patient-level data obtained from TF3 were anonymised by BSO ITS and made available in the Honest Broker Service (HBS) where we could also access healthcare data and external datasets within a secure and confidential environment (safe haven). In order to prevent patient identification, the HBS ensures that identifiable data are not accessible to researchers and that final analyses must have at least 10 individuals in any output. TF3 provided datasets to the HBS containing demographic data on each patient, along with data specific to their engagement with the telemonitoring programme. The HBS linked the TF3 data with BSO data already held by them.

The dataset used for the telehealth evaluation covered the period from the initiation of the service (9 December 2011) to 29 May 2015 (earliest and latest referral dates respectively). This was used for descriptive analyses of provision of, and engagement with, the service across the five HSC Trusts and across all conditions for which the service was offered. Data collected for the descriptive study were used within the HBS to support the analyses of the impact of the telehealth programme. Healthcare utilisation data, held in the HBS, were linked to patient datasets relating to hospital outpatient clinics (OP), accident and emergency (Symphony & NIRAES), hospital admission and discharge including day procedures (A&D) and prescribing and dispensing (Enhanced Prescribing Database-EPD). Associations between the provision of telehealth services and outcomes were assessed. The date of installation (or in the case of those not installed, the date of referral) was used as a time point to

demarcate whether telehealth had a subsequent effect on healthcare service interactions. Healthcare utilisation data were available for 20 November 2009 until 21 December 2015. Data were computed for each patient within this timeframe for the period before the installation date and for the period after the installation date. If a patient died after installation, an estimated date of death was inserted as the endpoint for that individual. For patients who were referred more than once, the earliest date of referral was selected as the initiation period for telehealth service provision.

For the economic component of the evaluation of telehealth, the patient-level non-elective healthcare service use collected in the effectiveness study was combined with unit costs to estimate a cost for each patient. This was costed before and after referral to the service and for the five different patient groups. Unit costs were based on the 2013/2014 financial returns of the HSC trusts in Northern Ireland which were obtained from the Department of Health, Social Services and Public Safety. Due to the lack of reliable Health Resource Group (HRG) coding in the linked data obtained from the HBS we could not assign specific unit costs to each non-elective stay. Instead, we based the unit costs on the weighted averages of the costs for each type of stay. For long stays of more than six days (weighted average length of stay of all non-elective long-stays), we attached an excess bed day cost for every day over. The unit costs for outpatient attendances and accident and emergency visits were similarly based on weighted averages. We bore in mind the patient demographic and did not include paediatric and pregnancy related HRGs in our calculations of weighted averages.

We used the TF3 dataset which included all patients who were referred to the service from 9 December 2011 until 29 May 2015 to estimate the cost of providing the service up until a cut-off date of the end of July 2015. Information on some of the costs associated with delivering the telehealth service was provided by the CCHSC. Four key cost components were identified: installation charge (£32), de-installation (removal) charge (£32), daily disease package charge and standing charge. The daily disease package charge reflected the costs associated with maintaining the equipment and was dependent upon the disease package the patient was receiving. For each patient referred to the service during the specified timeframe we calculated the cost to provide them with the telehealth service. We also calculated costs on an annual basis to provide a one year snapshot of the service. We costed for the whole service as well as for the four target conditions only.

When carrying out the questionnaire survey work to gather information of health related quality of life and self-care, two cohorts of telehealth patients were initially sought: Cohort 1 were patients referred to telehealth before 31 May 2015, forming a group of patients for a retrospective study, and Cohort 2 were patients referred to telehealth during the period June 2015 to September 2015, forming a group of patients for a prospective study. However, referrals to the telehealth service for the four target conditions during the recruitment period were much lower than anticipated and only eight patients agreed to join the study. Therefore, this element of the study was discontinued.

Patients were sought for the retrospective study (Cohort 1) from an anonymised list of eligible patients, i.e. referred within the specified time period and receiving telehealth services for COPD, diabetes, hypertension or heart failure, were prepared by the research team in the HBS. This list was de-anonymised by the HBS and passed to the service provider (Fold) who posted information packs to individual patients. Potential participants were asked to return a signed consent form and completed questionnaires to the research team. 1000 information packs were posted in the first week of November 2015, to all patients with hypertension and CHF and a stratified random sample of patients with diabetes and COPD. By 11 December 2015, 98 completed questionnaires had been returned and an additional 660 packages (to all remaining patients with diabetes and COPD) were mailed out by Ford during the second week of December 2015. A repeat mailing was sent to all those who had not responded in mid-January 2016. A total of 206 responses were received by 22 February 2016.

The primary approach to collecting qualitative data on the views of patients was via focus groups. Five focus groups incorporating the four target conditions were held. Telehealth Service Managers (TSMs) in each Trust were asked to identify patients who would be able to take part in a focus group discussion, with a range of the conditions being studied, and some with multi-morbidity, in order to get a good representation of patients who have received the service. A study information sheet, invitation letter, consent form and stamped addressed envelope were distributed to potential participants. Focus groups were convened at a time and place convenient to participants, and a topic guide directed discussion. Topics included perceived value of telehealth monitoring in self-care, educational aspects of the service, engagement with the service and healthcare providers, confidence in using equipment, user-friendliness of equipment, confidence placed on readings taken, interactions with healthcare professionals during their period of equipment use, and perceived value of participation in the programme (e.g. peace of mind through self-monitoring). Participants were encouraged to introduce other topics of interest and importance. All focus group discussions were audio recorded and participants were assured that all comments made were non-attributable (kept confidential) and that their names would not appear on any study reports.

To supplement the focus group discussions, three additional groups of participant were recruited:

- Patients with stroke who had used the service. These patients were interviewed at home together with their carers (as appropriate), using the range of questions addressed in the focus groups.
- Patients who were offered the service and declined, or who were discharged early due to engagement issues. These patients were identified using the Telemonitoring dataset accessible via the HBS and were sent invitations by Fold. The topic guide for the interviews with patients who agreed to join the study included questions similar to those used for the focus groups but with additional questions to ascertain reasons for declining the service or being discharged early.
- Carers of patients were interviewed to gain insight into their experiences of telehealth, with recruitment facilitated by the telehealth key workers.

A sample of healthcare professionals, from different professional groups who were involved in the delivery of the telehealth service (triage nurses, service development managers in Trusts, telehealth NI key workers (i.e. specialist community nurses) or who had the potential to be involved in the future (general practitioners (GPs), community pharmacists, hospital doctors) took part in telephone interviews. Telephone interviews covered a similar range of topics to those in the focus group discussions with patients and were continued until data saturation was reached for each healthcare professional grouping. If healthcare professionals were not currently involved in telehealth delivery they were asked from the perspective of their potential engagement with the service.

All interviews were recorded, fully transcribed verbatim by an independent transcriber and the transcript checked against the recording. Each group of participants (health professionals, focus groups, carers, stroke patients and patients discharged/declined) was analysed separately. To ensure minimisation of researcher bias during theme development, two researchers independently coded the transcripts and developed themes using the constant comparative method. Codes were recorded using NVivo. Themes were discussed with the wider research team to help further refine the analyses and a thematic framework was developed in line with the approach and aims of this study. A constant comparative method was used and agreement was reached between the researchers on the discovered themes.

Two datasets were used in the evaluation of telecare. The complete dataset for which electronic records were available was used to review the uptake of the service and a subset was used to examine, for example, hospitalisations pre and post installation of the telecare equipment. This subset excluded: (i) Patients who had no installation date specified in the data sets, (ii) Patients who had telecare installation within the first 6 months from the starting date (26 February 2010) and (iii) Patients who had telecare installation within the last 6 before the end date (22 February 2016). These exclusions were required to allow calculation of events per year (with a six month period the minimum observation period on which to base the calculations). Individual patients were matched with their routine healthcare utilisation data. The date of installation was used as the cut point to demarcate pre and post telecare use. Healthcare utilisation data were available for the period 26 February 2010 until 22 February 2016. Data were computed for each patient within this timeframe for the period before the installation date and for the period after the installation date (a minimum of 6 months data pre and post installation were required for patient inclusion, as detailed above). If a patient died after installation, date of death was inserted as the endpoint for that individual.

Findings

Descriptive summary of the uptake of the telehealth service

There were 4216 referrals to the telehealth service between December 2011 and May 2015, for a total of 3944 individual patients, with 1030 patients on the service at the end of July 2015. The total cost of the telehealth service for this period has been estimated as approximately £6,745,000. The mean number of installations per quarter was 248, with a range from 110 to 426 installations. There were

1671 referrals for the triage service and 2545 for the track and trend service. Most patients (3691) were referred once only, 235 were referred twice (470 referrals) and 18 were referred three times (54 referrals). Most referrals (3815 or 90.5%) were classified as 'standard' referrals, with 401 (9.5%) classified as 'urgent' referrals. General characteristics of the full dataset are given in Table 1, followed by summary information on some patient variables. Referral numbers by Trust are: NHSCT (1228 referrals), SHSCT (968), WHSCT (834), SEHSCT (730) and BHSCT (456).

Table 1 General characteristics of total dataset (timeframes and referral numbers)

Procedure	Earliest	Latest	Notes
Referrals	09 Dec 2011	29 May 2015	All 4216 have a referral date. 408 referrals were not installed.
Installation	12 Dec 2011	28 May 2015	3808 have an installation date. 2778 have an installation and discharge date. 1030 installed referrals are still on the service (no discharge date).
Discharge	21 Dec 2011	09 Oct 2015	2778 have a discharge date. 92 of which have been discharged but equipment had not been removed.
Removal	11 Jan 2012	24 Sep 2015	2692 have a removal date. Of the 92 with no removal date: 27 are deceased.

More females (2294, 58.2%) than males (1650, 41.8%) were enrolled in the telehealth service. Patients ranged from 4 to 99 years of age, with a mean of 57.6 (standard deviation: 19.8) and median of 63 years. Most patients were Caucasian (3859) and most (3922) had English as their first language. Most referrals (4055) were reported to have no communication issues and, similarly, most patients (3861) using the telehealth service were reported not to have any cognitive impairment. However, 61 were classified as having a mild cognitive impairment and 22 as having a moderate or severe cognitive impairment. Most patients (3044) did not have a recorded physical impairment, but 610 were mobile with aids (including wheelchair users), 203 were reported to be mobile at home only and 45 were recorded as having no mobility. The remaining 42 had some other mobility issue recorded, for instance, back/knee/feet problems, prosthetic leg, paralysis of one side of body, uses ambulatory oxygen, osteomyelitis (foot), slow movement, bed bound and visual impairment which restricts mobility.

Patients were predominantly referred for six single conditions: COPD, diabetes, weight management, stroke, heart failure and kidney problems. Other conditions included co-morbidities, such as diabetes with weight management, CHF with COPD, COPD with other comorbidities and hypertension only. The most common disease packages included: diabetes home based (1395), COPD (976), diabetes mobile (562), stroke (371), heart failure (325) and COPD with BP (290). It should be noted that many patients who were supplied with a diabetes package were receiving this for weight management.

The 'proposed length of monitoring' is set at the time of referral with the maximum length restricted to 364 days. Many referrals were renewed, which accounts for the longer upper limit within duration of monitoring in the variable 'actual length of monitoring'. The 'proposed length of monitoring' variable ranged from 7 to 364 days (median 182 days) while the actual length of monitoring ranged from 0 to 1387 days (median 161.5 days). 1030 referrals had no 'actual length of monitoring' recorded, since this

sample included patients who were still on the service and have not yet been discharged. Most referrals (1819) involved patients submitting data weekly; 1092 were recorded as submitting data daily, with 927 on weekdays only and the remaining 378 submitting data at another frequency (including weekends).

The 2011 Super Output Areas (SOAs) were used to examine the distribution of the addresses of telehealth service users against deprivation indices. 4171 out of the 4216 referrals had an associated address and our analysis indicate that there was an under-representation of patients from the least deprived deciles for both the Multiple Deprivation Measure (MDM) and proximity to services subscale.

We performed cross tabulations to characterise the distribution of the services across Trusts and patient groupings, which revealed differing levels of patient participation across Trusts. For example, NHSCT was the only Trust to refer patients in the age category 0-19 years, due to their significant adoption of the service for weight management for younger patients. Although NHSCT had the highest number of patients overall, and the highest number of referrals for weight management, its numbers are lower for the target conditions for this study. SEHSCT and WHSCT had high referrals for COPD and diabetes. SHSCT and NHSCT had higher referrals for heart failure and hypertension, respectively (driven by the level of engagement by clinicians referring patients for telehealth monitoring).

Quantitative evaluation of the telehealth programme

206 patients who received telehealth services for the targeted conditions completed the questionnaires for the retrospective study of self-care: 94 (46%) COPD; 67 (33%) diabetes mellitus; 32 (16%) heart failure (HF), and 13 (6%) hypertension (HTN). All patients were asked to complete the same set of generic self-efficacy and generic health-related quality of life questionnaires, i.e. General Self Efficacy (GSE), European Quality of Life - Visual Analogue Scale (EQ VAS) and the European Quality of Life Index (EQ-Index) questionnaires. In general, patients with COPD and HF reported lower scores (poorer health-related quality of life and self-efficacy) compared to patients with DM and HTN (Table 2).

Table 2 Participant scores (mean \pm SD) for GSE, EQ VAS and EQ-5D-5L across the different health conditions

Outcome measure	COPD (n=94)	Diabetes Mellitus (n=67)	Heart Failure (n=32)	Hypertension (n=13)	Total (n=206)
GSE score ^a	2.7 \pm 0.7	3.0 \pm 0.7	2.7 \pm 0.9	3.1 \pm 0.8	2.8 \pm 0.7
EQ VAS ^b	49.2 \pm 21.0	60.6 \pm 23.4	52.1 \pm 20.5	69.6 \pm 26.2	54.6 \pm 22.8
EQ-5D-5L Index ^c	0.353 \pm 0.304	0.534 \pm 0.348	0.433 \pm 0.323	0.689 \pm 0.365	0.445 \pm 0.338

^a GSE: General Self Efficacy - score range is from 1 to 4. Higher number indicates higher self-efficacy.

^b EQ VAS: European Quality of Life questionnaire - Visual Analogue Scale: This scale ranges from 0 to 100. 100 means the best health you can imagine. 0 means the worst health you can imagine.

^c EQ-5D-5L Index: European Quality of Life questionnaire; Score range is from -0.594 to 1. 1 means the best health you can imagine.

The complete cohorts of patients who had received / continued to receive telehealth services for the four targeted conditions (total: 1959 patients) were included in the analysis of healthcare use and Table

3 shows the data available for the five categories that we used to make comparisons between people who were referred and did or did not receive the service.

Table 3 Numbers of patients within each of the groups used in the before and after analyses

Group*	Group descriptor*	HF	COPD	DM	HTN	Total
(i)	Never installed	20	46	49	4	114
(ii)	Successful	106	188	283	16	571
(iii)	Not successful	30	93	128	4	249
(iv)	Discharged	36	130	133	3	289
(v)	Ongoing	93	466	187	16	736
(vi)	Installed	265	877	731	39	1845

Approximately 18% of the patients who received or were scheduled to receive telehealth monitoring for one of the four targeted conditions died during the follow-up period. There was a marked difference in mortality rates between the 'Never installed' group and patients who had telehealth services put in place (33.3% versus 13.9%). This was particularly true in the first year after the referral date, meaning that the mortality results need to be interpreted with caution when the 'Never installed' group is used as the quasi-control group, because some deaths occurred so soon after the referral date that these are unlikely to have been prevented by the installation and use of the telehealth equipment.

The data for non-elective hospital admissions, pre and post the implementation of telehealth services, for the 'Never installed' versus the 'Installed' grouping for the four target conditions combined show that the mean number (SD) of non-elective admissions to hospital for the total patient cohort increased slightly in overall terms from 0.8 (1.0) and 0.7 (1.0) admissions/year to 1.2 (2.2) and 1.1 (2.2) admissions/year after the index dates in the 'Never installed' and 'Installed' groups respectively. There was no statistical significant difference between the two groups ($p>0.05$), where this p-value and those given below relate to the change (before minus after) in the never installed group versus the change (before minus after) in the installed group. Patients with HF showed an anomalous decrease in the mean number of admissions from 1.3 (1.5) to 0.6 (0.9) admissions/year in the 'Never installed' group and an increase from 0.9 (1.0) to 1.2 (1.6) admissions/year in the 'Installed' group ($p<0.05$). The data for length of hospital stay, presented in mean number of hours per year, pre and post the implementation of telehealth services, for the 'Never installed' versus the 'Installed' groups of patients for the four target conditions combined show that the mean length of stay (SD) in hospital increased from 165.6 (260.9) and 108.6 (231.5) hours /year to 203.8 (433.1) and 200.8 (503.6) hours/year after the index dates in the 'Never installed' and 'Installed' groups, respectively. There was no statistically significant difference between the two groups ($p>0.05$). Again, linked to the anomalous decline in hospitalisations for the 'Never installed' patients with HF, there was a statistically significant difference for these patients, with a decrease in average length of stay from 304.8 (418.8) to 110.6 (195.1) hours/year in the 'Never installed' group, compared to an increase in average length of stay from 171.2 (263.4) to 267.5 (559.7) hours/year in the 'Installed' group. The data for emergency room visits per year, pre and post the implementation of telehealth services, for the 'Never installed' versus the 'Installed' groupings for the four target conditions combined show that the mean number (SD) of emergency visits for the total

patient cohort changed from 1.2 (1.3) and 1.1 (1.5) visits/year to 1.2 (2.3) and 1.5 (2.5) visits/year after telehealth introduction in the 'Never installed' and 'Installed' groups respectively. There was a statistical significant difference between the two groups, i.e. a greater number of emergency room visits post telehealth implementation in the 'Installed' group. As was the case with hospitalisations, patients with HF exhibited a decrease in the average number of emergency visits from 1.7 (2.0) to 0.6 (0.8) visits/year in the 'Never installed' group and an increase in the average number of emergency visits from 1.1 (1.2) to 1.3 (1.6) visits/year in the 'Installed' group ($p < 0.05$). The data for outpatient visits per year, pre and post the implementation of telehealth services, for the 'Never installed' versus the 'Installed' groupings for the four target conditions combined show a significant difference in the average number of outpatient visits, with visits becoming more likely after implementation in the 'Installed' group.

Health economic analysis of the telehealth programme

Since reliable data on GP visits / call-outs were not available, our economic analysis focused on the use of hospital-based services. The results mirror our findings for average length of stay, as hospital 'hotel' charges dominate overall costs of healthcare delivery. In general, annual costs were higher after enrolment but the changes were not statistically significantly different between the patient categories in relation to receipt of telehealth. For instance, the mean cost per year in the 'Installed' group was £4876 (5919) before versus £5758 (10,156) after enrolment, compared to £3679 (5229) and £5941 (11,278), respectively, for the 'Never installed' group.

Patient views of the telehealth programme: focus groups

A focus group was held in each Trust, ranging in size from three to seven participants and incorporating patients and their carers. Fifteen patients attended (COPD: 8; diabetes: 6; and heart disease: 1). They were unanimously positive about telemonitoring, with the main benefit being the reassurance it gave them that a health professional was monitoring them constantly. Some patients, particularly those with COPD, reported real clinical benefits because telemonitoring acted as an early warning system. For instance, early indications of infection were picked up by triage nurses because readings were observed daily, allowing treatment to be started quickly. Patients said that there was no doubt that this had saved them hospital stays. Analysis of the data led to the identification of the following themes: impact on health and healthcare utilisation, incentive for use, reassurance and support, empowerment and education, routine and convenience, resources and dependence, and continuation. Many patients said that telemonitoring had made a significant impact on their health and hospital stays. Overall, patients said that their contact with health professionals had been less often since having telemonitoring, and that they welcomed this. Contact with professionals connected with telemonitoring, including specialist nurses and triage nurses, was unanimously praised, and encouragement from health professionals helped develop confidence for patients. Patients also derived satisfaction from their belief that they were visiting their healthcare professional less often. Peace of mind was a major theme with participants stating that this was perhaps the biggest advantage of telemonitoring. Patients derived reassurance not only from knowing that their symptoms were stable and that a professional was keeping a constant eye on them, but also through believing that they were less of a burden on the health service. Family

members also experienced great reassurance from knowing that their loved one was being monitored regularly. Patients spoke of learning more about their own condition and becoming confident in this increasing knowledge of what their normal readings should be. They reported that taking their readings at set times during the week became part of their routine and was not disruptive, and that they had found telemonitoring to be extremely convenient because of how simple it was to use. Many patients expressed strong support for the continuation of the service, and some dreaded the thought it discontinuing.

In the sub-study of stroke patients, four patients were interviewed in their own homes. They were generally using the service for a few months and, like patients and carers described above, they were overwhelming positive about telemonitoring. They appreciated the information they received with regular contact from health professionals, in particular their stroke specialist nurse.

Six carers of patients who use telemonitoring (COPD: 5; diabetes: 1) were interviewed. They were spouses, children or friends of the patients. Analyses revealed similar themes emerging from the data, ie, impact on health and healthcare utilisation, reassurance and support, convenience, and improved education and self-care. Carers recognised that telemonitoring was convenient not only for themselves but professionals as well. Only one carer expressed negative views of telemonitoring, which were focused on the system not being tailored specifically enough for the patient.

Fold sent invitations to 100 patients who were discharged unsuccessfully or who declined telehealth. Two agreed to take part but one of these did not answer subsequent phone calls. An additional participant was recruited via the quantitative study. The two patients were interviewed by telephone. One did not know he had been referred to receive the service and it was never installed, and another found that it was unnecessary after it was offered to her after being prescribed insulin for diabetes. She felt that she had never had a problem controlling her condition, and mentioned becoming stressed and frustrated when she was unable to get blood sugar levels uploaded on to the system.

The response rate for health professionals invited to take part in the telehealth evaluation was 52.3%.

Table 4 Number of health care professionals invited and interviewed

	Invited	Interviewed
Telehealth key worker	28	7
Service development manager	16	8
Pharmacist	12	10
GP	14	8
Triage nurse	10	9
Hospital doctor	16	3
Total	86	45

Table 4 shows the six groups of health professional categorised into those who worked directly with telemonitoring, i.e., telehealth key workers (specialist nurses in the community), service development managers and triage nurses; and those who did not (i.e. pharmacists, GPs and hospital doctors).

Among the healthcare practitioners who did not work directly with telemonitoring, most views were perceived because they had no direct experience of telemonitoring. There was some hesitation in accepting telemonitoring without a stronger evidence base, and concerns over costs. The main themes identified from analyses of the interviews were awareness of telemonitoring, the potential of telemonitoring, information sharing, impact on face-to-face contact, convenience and reassurance, impact on self-care, impact on healthcare professionals and concerns about telemonitoring.

Pharmacists had little or no knowledge of telemonitoring, while GPs said that they were officially informed if patients had received telemonitoring or knew about it because patients had told them that they were using the service or were receiving telephone calls from community nurses monitoring their telemonitoring results. One of the three hospital doctors interviewed knew about the service because he had been to a training event when telemonitoring was being introduced to the health service. The other two doctors said they would only know which patients were on telemonitoring if the patients themselves told them.

Healthcare professionals perceived that telemonitoring had specific potential in terms of what it could do, and the types of patients who should be targeted. Communication between different health professions, such as GPs and pharmacists, was said by most pharmacist interviewees to be poor. It was also stated that information sharing could be useful to assist patients who were having difficulties with using the telemonitoring devices and that patients would also feel reassured if the pharmacist knew they were using telemonitoring. The issue of maintaining face-to-face contact with health professionals was discussed and pharmacists perceived that telemonitoring may result in reduced contact. Some believed that this could have negative consequences, but contact via telemonitoring and knowing that readings are being monitored was perceived by some as being better than no contact. Hospital doctors and GPs agreed that face-to-face contact was important and that there were wider negative implications if this was reduced. Convenience and reassurance were perceived as key benefits by health professionals. Health professionals spoke of the reassurance they believed patients would feel from constant monitoring, as well as that which they would also have because a reassured patient tends to feel better. As the importance of healthy living is being increasingly promoted, participants said it was important for patients to take more responsibility for their own health. While GPs were overall sceptical that telemonitoring would result in significant health improvement, they believed that it could enable greater self-care and education. Telemonitoring was reported to impact on healthcare professionals in terms of their workload, patterns of working and use of information and participants said they believed their workload may be reduced with increased use of telemonitoring.

The health professionals who engaged directly with telemonitoring (triage nurses, telehealth key workers and service development managers) raised similar themes to the other health professionals

but spoke from more direct knowledge of the service. All said that reassurance and support for patients and their families was a major benefit of telemonitoring. They agreed that shared information was very useful and triage nurses suggested that telehealth key workers should share more details on their patients. Telehealth key workers said that the information available from telemonitoring was useful when they needed to share it with other professionals. Triage nurses spoke of the unique advantage their position offered because with constant monitoring they can escalate care for a patient if necessary and accurate readings were said to be a significant advantage of telemonitoring. A manager said that the aim of telemonitoring was to educate the patient and to enable them to develop enough confidence in managing their own condition that they are not as reliant on professionals. A major challenge for telemonitoring was mentioned by a number of service development managers as that of dealing with patients with co-morbidities. In general, professionals said that telemonitoring should ease workload but one key worker said that the service had actually increased her workload. Health professionals were also said to feel reassured knowing that their patients were under constant monitoring. All participants spoke about the support which patients experienced from telemonitoring. Triage nurses spoke of the new skills they developed because of communicating with patients solely by telephone. A specialist nurse said that patients did not mind having less face to face contact because of the opportunity to talk to triage nurses at any time. Everyone agreed that patient selection was crucial to successful telemonitoring, and communication was central to this in terms of identifying the right people. Some participants spoke of the convenience for health professionals that telemonitoring offered.

Professionals said they had witnessed an improvement in self-care among patients using telemonitoring. While most health professionals, including telehealth key workers, agreed that telemonitoring fostered an improvement in self-care, two of specialist nurses said they had found the opposite. However, there were some general concerns about how telemonitoring could lead to an element of dependency in patients. Resources were an important consideration in terms of both equipment and appropriate use of manpower. Some participants spoke of difficulties with equipment, either as a result of instruments giving inaccurate readings or battery operated monitors. However some professionals pointed out the advantages to be gained from the technology. When asked about further developments for telemonitoring, a number of participants raised the possibility of video consultations, more health promotion and new observations to be monitored.

Descriptive summary of the uptake of the telecare service

Demographic data are available for a total of 2387 individual patients, but some of these patients did not have telecare related data available. 14 patients were referred twice. The number of patients by Trust are: BHSCT (478 patients), NHSCT (416), WHSCT (226), SEHSCT (119) and finally 'unknown', which also includes patients from the SHSCT (1148). The latter two groups (unknown and SHSCT) were combined because there were so few participating patients within the SHSCT that the HBS would not permit the SHSCT data to be analysed separately. More females (1617 or 67.7%) than males (770 or 32.3%) were enrolled in the telecare service. Their ages ranged from 4 to 114 years, with a mean of 77.8 (SD: 12.2) and median of 81 years, and an imbalance of more females in all age groups. There

were between 1 to 10 items of equipment installed in patients' homes, with a mean of 2.6 (SD: 1.7) and median of 2 items of equipment per patient. 2330 patients had call information and 57 did not. There were between 1 to 7183 calls per patient, with a mean of 86.8 (SD: 235.7) and a median of 33 calls. The vast majority of patients whose service had been terminated had no reason given for termination (1119). Reasons that were given were: removed from PNC (64), gone into care (27), deceased (25) and no longer needed/cancelled (19).

Quantitative evaluation of the telecare programme

Data were available for 1883 individuals who were referred between 26 February 2010 and 22 February 2016 and had data covering a minimum of 6 months pre and post their installation date. However, because no control data were available, the following data are simply descriptive of the changing frequency of events for the time periods before and after installation. It is not possible to determine if the increase is due to the telecare service or other factors. There were significant increases in mean healthcare use after installation. For example, the average number of non-elective admissions to hospital increased from 0.5 (SD: 0.6) admissions/year to 1.0 (1.5) admissions/year ($p < 0.05$) and the average length of hospital stay increased from 115.3 (SD: 190.6) hours/year per patient to 232.2 (485.2) hours/year after the installation ($P < 0.05$).

Conclusion

This project was complex with broad aims and objectives. We used a mixed methods approach, involving surveys, the interrogation of existing and linked administrative databases, and qualitative approaches (focus groups and interviews) as is current best practice in this type of research, but which also brings some challenges.

The data within the descriptive analyses covered the complete programme of implementation of the telehealth service from December 2011, for all conditions, not just those that are the focus of other parts of this report. There was a steady stream of installations over the period. This is a very impressive roll-out of a new, complex service requiring very considerable administration and management. Engagement was good across all Trusts, but with varying patterns in relation to the types of patient who were referred.

In our quantitative study, the response rate was lower than anticipated from the group of patients who had received or were receiving this new and innovative service for the four targeted conditions. This limited our ability to compare and contrast the findings across different types of patient or with other studies. Nonetheless, the 206 survey forms returned were in general well completed, demonstrating good engagement of those who participated. As expected, health related quality of life was lowest in patients with COPD and heart failure, with higher scores being obtained in patients with diabetes and hypertension. Review of literature values for health related quality of life in the target disease groups indicated that the present telehealth cohorts had values either similar to or lower than published mean values, indicating that the case mix of patients involved was at the more serious end of the disease

spectrum. General self-efficacy scores mirrored those for health related quality of life, with higher self-efficacy scores noted in patients with hypertension and diabetes. Disease specific self-efficacy was slightly higher for the present cohort, when compared with the published norm for COPD patients, but slightly lower in the cases of diabetes and heart failure, i.e. no consistent evidence that self-efficacy (and therefore self-care) was enhanced through use of the service in this point prevalence study. When the quality of life scores and general self-efficacy scores were examined across the different categories of patients of 'not successful', 'successful', 'discharged' and 'ongoing', the data were very similar across all groups indicating that within this cohort of patients, health related quality of life and general self-efficacy were relatively stable and not influenced by the telehealth service provision.

By far the most striking finding within this part of the overall evaluation was the finding of a higher mortality rate (33.3%) within the quasi-control, 'Never installed' group compared with the 'Installed' group (13.9%). Although tempting to infer that the results are indicative of the alerts generated by telehealth monitoring facilitating the early implementation of life saving interventions, it is likely that at least some of these patients did not have equipment installed because they had become morbidly unwell. Decreased mortality due to telemonitoring has, however, also been demonstrated by Dendale *et al.* (2012) in a study involving telemonitoring in a group of 160 patients with heart failure, but this was not reflected in a larger study (Chaudhry *et al.*, 2010). Decreased mortality has also been demonstrated in the Whole Systems Demonstrator Project (Steventon *et al.*, 2012), the largest controlled clinical trial to date on telemonitoring (Cartwright *et al.*, 2013).

Although there were a number of testimonials from the participants in the patient focus groups regarding reduced hospitalisations and a reduced need to attend outpatient clinics, this did not carry through to the data obtained in the effectiveness aspect of the current evaluation. In general terms, the number of hospitalisations, length of hospital stay and outpatient clinic attendance (and therefore overall cost of healthcare provision) did not differ between the quasi-control 'never installed' group and any of the groups who received some amount of telemonitoring. The results, where they were statistically significant, were largely driven by an anomalous result for the heart failure 'never installed' group.

Support for the telehealth service was overwhelmingly positive, particularly from patients (and their carers) who used the service. Healthcare professionals were generally positive, but much more guarded, particularly those who had little or no direct experience of the service. Reassurance was a major theme throughout patient and carer interviews and focus groups. Many said that feeling reassured that a health professional was monitoring their condition allowed them to carry on with as normal a life as possible. This was a common view among patients with all conditions. It is in keeping with a qualitative study of heart failure patients using telemonitoring by Fairbrother *et al.* (2014), which also identified reassurance as an important theme. Healthcare professionals and patients reported that telemonitoring data had assisted in medical treatment decisions, and diabetes patients noted that the service had encouraged maintenance of a healthy diet. This use of data and the motivation of self-care

were also found by Hanley *et al.* (2015) in 23 diabetes patients using telemonitoring for blood glucose and blood pressure.

Healthcare professionals pointed to the potential problem of patients becoming dependent on telemonitoring, again highlighting the need for careful patient selection and review. Some patients acknowledged that they relied on the service and fought against its discontinuation from their programme of care, arguing that it had prevented their need for hospitalisation or repeated clinic visits. While health professionals tended to identify difficulties with the equipment, including that it needed updating, patients had a contrasting view. The fact that the monitoring devices were simple to use was considered by patients to be of significant benefit, particularly for patients with serious illnesses for whom dealing with more complicated technology may have been stressful. Healthcare professionals suggested new approaches which could be added to existing services, such as video consultations, but patients were generally satisfied with the current approach saying that improvements and upgrades were not needed.

Alongside their more guarded support for telemonitoring, healthcare professionals expressed their view that they wished to see more evidence of effectiveness. A number also expressed their view on the importance of face-to-face contact with patients and that robust self-care approaches involves much more than monitoring. They also raised the expense of the service and the anxiety that could be caused when the service is discontinued for a particular patient. Generally, healthcare professionals who were not directly engaged with the service felt that much better systems of communication and information sharing were required.

In summary, the main impact of the telehealth service according to the objective findings in this evaluation is on mortality, while in subjective terms it is on peace of mind for the recipients of the service. The main limitation of the research is that the work evaluated a service that was already up and running without a robust control group and largely depended on routine administrative information rather than information collected to standards generally needed for research purposes, and as such the strength of the evidence is compromised. The greatest challenge was gaining approvals to retrieve, link and use datasets which were owned by the HSC Trusts and held by TF3. The procedures for gaining such access were new and initially considerably slowed progress with the research. The data structures prevented access to the exact data desired for some of the analyses and the delays and lower than expected number of referrals in mid-2015 also caused problems. A further limitation was the lack of availability of primary care health utilisation data. Nonetheless, the work does allow the development of the recommendations in this report.

In regard to the telecare study, the high number of 'calls' from patients who had the telecare equipment installed indicate that the patients for whom the services were installed were high dependence patients and it seems likely that appropriate actions by the telecare team led to the prevention of negative health outcomes for them, perhaps through recourse to the healthcare services

that we were able to investigate. However, the main limitation of this part of this study is the lack of control data which means that it is not possible to assess the impact of the service as distinct from any other factors that might have had an effect. Comparative data for cohorts of patients with similar care requirements who did not have telecare services put in place would have allowed us to investigate these confounding factors. For example, it is to be expected that as patients get older, they are more likely to use hospital based services. Ideally, a controlled, randomised trial is needed to determine and quantify the impact of telecare services. This would help determine the effects and cost-effectiveness of this service which intuitively should make an important difference to patients who need assistance with their independent living in the community.

Practice and policy Implications/Recommendations

1. Engage other health care professionals (including GPs and community pharmacists) through improved information flows.
2. Evolve the intervention within a complex intervention framework (rather than simply self-monitoring) with formal education provision on disease state, medication management, management of anxiety and depression, and self-management of symptoms.
3. Collect data alongside the delivery of the programme that could be used for research purposes with minimal disruption to the delivery of the service, such as that needed to undertake an interrupted time series analysis. Patients on enrolment could be asked to provide written consent that their data could be used for research purposes. If the service is oversubscribed, patients could be randomly allocated to the service, and as such a robust control group would naturally be in place for further service evaluation.
4. Develop strict rules for patient selection for inclusion in the service, including how co-morbidity is addressed (perhaps using a simpler referral documentation).
5. Develop strict rules for withdrawal from the service, making these clear to patients from the outset.
6. Consider the lessons learned about the use of the routine administrative data and its linking to data held by the Honest Broker Service in any future discussions of how these data are stored and accessed in order to facilitate future evaluations of this type.
7. Carry out a randomised trial of the telecare service to inform the future development of the service. This might be done as part of any expansion of the service, for example by randomising patients for whom the benefits of the service are uncertain to either receive or not receive it, or randomly allocating such patients to receive it immediately or after a period of 12 or more months, during which time they would act as control patients.

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