Supplemental Material

Table S1: Typical peripheral configurations for a patient with chronic obstructive pulmonary disease

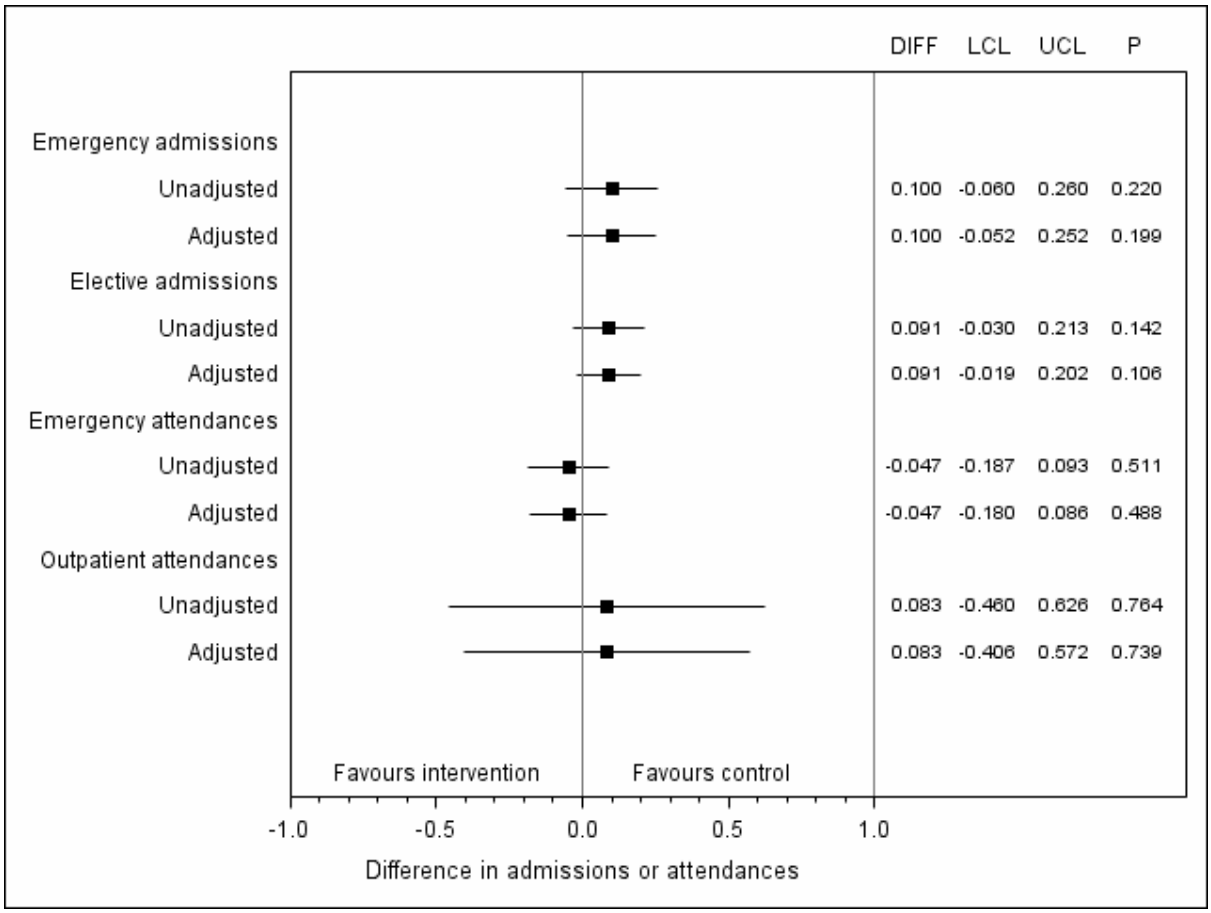
	Telehealth peripherals				
	Blood Pressure Monitor	Pulse Oximeter	Theromo-meter	Peakflow Monitor/ Spirometer	Health Interview
Chronic obstructive pulmonary disease	Yes	Yes			Yes
Severe chronic obstructive pulmonary disease	Yes	Yes	Yes		Yes
Chronic obstructive pulmonary disease requiring breathing monitoring	Yes	Yes	Yes	Yes	Yes

Table S1: Secondary (difference-in-difference) analysis on patients enrolled before 30 September 2012 - Estimated intervention effects for hospital utilisation

	Telehealth patients (n=672)			Control patients (n=635)				
	Six months before enrolment	Six months after enrolment	Difference	Six months before enrolment	Six months after enrolment	Difference	Difference in difference (95% CI)	P-value
Emergency admissions	1.18 (1.42)	0.70 (1.23)	-0.47 (1.57)*	1.08 (1.38)	0.51 (1.10)	-0.57 (1.47)*	0.10 (-0.062, 0.262)	0.199
Elective admissions	0.39 (0.93)	0.34 (1.08)	-0.05 (1.07)	0.43 (0.82)	0.29 (0.84)	-0.14 (0.95)*	0.091 (-0.019, 0.202)	0.106
Outpatient attendances	4.46 (5.22)	3.46 (4.00)	-0.99 (4.95)*	4.12 (4.99)	3.04 (4.10)	-1.08 (4.59)*	-0.047 (-0.180, 0.086)	0.488
Emergency department visits	0.91 (1.34)	0.56 (0.99)	-0.35 (1.31)*	0.83 (1.21)	0.53 (1.13)	-0.31 (1.32)*	-0.083 (-0.406, 0.572)	0.739
Bed days (total)	10.81 (16.02)	6.72 (15.08)	-4.09 (18.73)*	11.51 (20.78)	7.10 (18.23)	-4.41 (24.41)*	0.326 (-2.1113, 2.762)	0.794
Bed days (after emergency admission)	9.21 (14.48)	5.62 (13.06)	-3.59 (15.78)*	8.94 (15.93)	5.55 (15.22)	-3.39 (19.23)*	-0.200 (-2.201, 1.800)	0.844
Bed days (after elective admission)	0.77 (2.68)	0.61 (2.87)	-0.16 (3.69)	1.32 (6.43)	0.78 (3.94)	-0.54 (7.40)	0.376 (-0.262, 1.005)	0.240

Data are mean number per patient (standard deviation). *Difference = $P<0.05$ CI = confidence interval

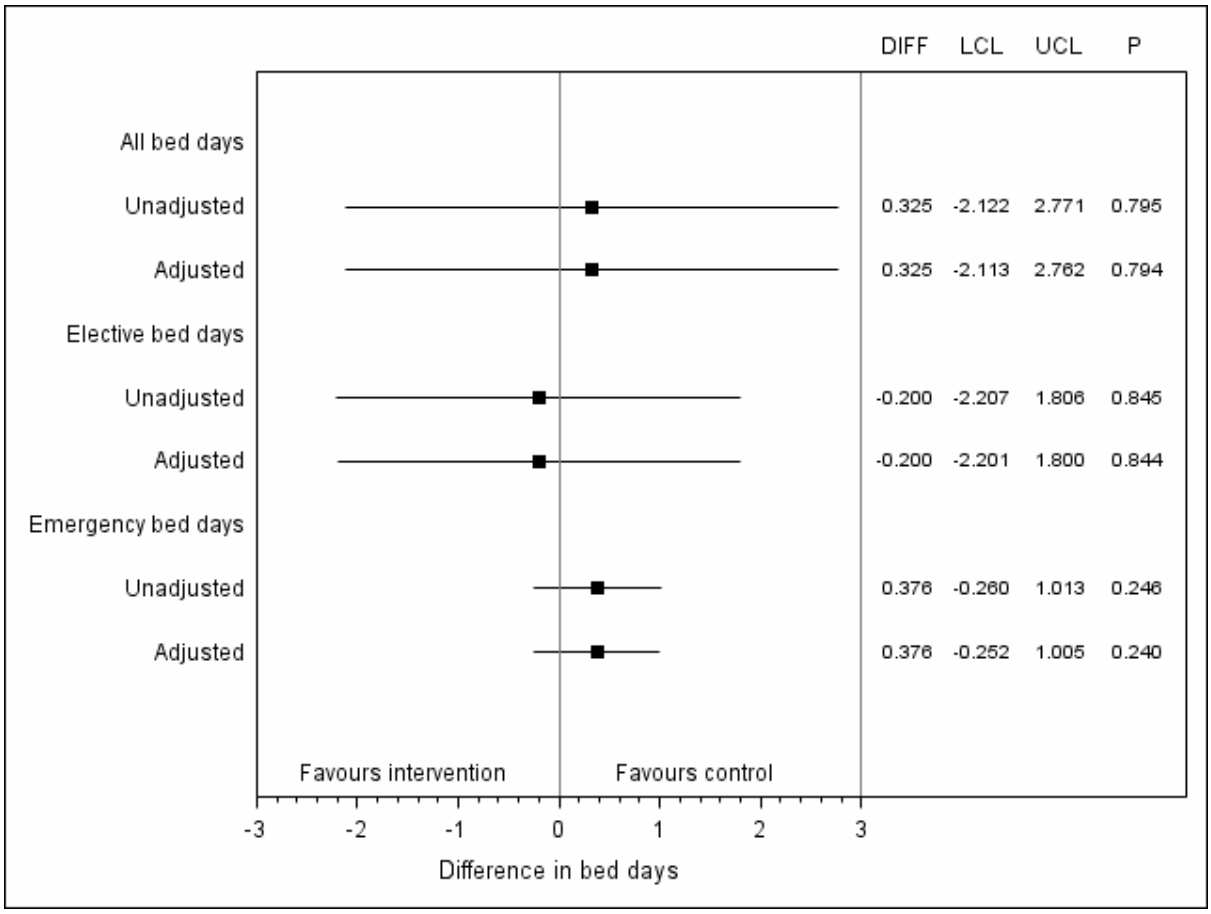
Figure S1: Secondary (difference-in-difference) analysis -Estimated differences in admission and attendance categories and 95% CIs (n=1307)



DIFF = difference in difference estimate from random effects linear regression analysis, LCL = lower 95% confidence interval for difference in difference estimate, UCL = upper 95% confidence interval for difference in difference estimate, P = p-value of the null hypothesis the difference is equal to zero.

Results adjusted for age (entered as a continuous variable), gender, socioeconomic deprivation decile, ethnicity, previous history of specific conditions (anaemia, angina, asthma, atrial fibrillation and flutter, cancer, cerebrovascular disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes, falls, injury, hypertension, ischaemic heart failure, kidney failure, mental health condition, peripheral vascular disease), number of long term conditions, predictive risk score, emergency admissions (previous year), elective admissions (previous year) and outpatient attendances (previous year)

Figure S2: Secondary (difference-in-difference) analysis - Estimated differences in bed days and 95% CIs (n=1307)



DIFF = difference in difference estimate from random effects linear regression analysis, LCL = lower 95% confidence interval for difference in difference estimate, UCL = upper 95% confidence interval for difference in difference estimate, P = p-value of the null hypothesis the difference is equal to zero.

Results adjusted for age (entered as a continuous variable), gender, socioeconomic deprivation decile, ethnicity, previous history of specific conditions (anaemia, angina, asthma, atrial fibrillation and flutter, cancer, cerebrovascular disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes, falls, injury, hypertension, ischaemic heart failure, kidney failure, mental health condition, peripheral vascular disease), number of long term conditions, predictive risk score, emergency admissions (previous year), elective admissions (previous year) and outpatient attendances (previous year)

Post-hoc sub-group analyses

Analysis of Haxby Practice patients

Introduction

One of the hypotheses suggested for the lack of evidence of effectiveness of the telehealth program was that a large proportion of the patients recruited had come from a single set of general practice patients (the Haxby practice) who had used different referral criteria than the programme design. Specifically, the Haxby practiced managed telehealth patients differently by employing a dedicated nurse manager in the practice and the local programme was targeted at reducing general practice contacts. This sub-group analysis examines this hypothesis.

Identification of patients

No recent patient list was available to identify Haxby patients. Instead, Haxby patients were identified from general practice codes recorded on HES hospital data or, if that was not possible, by examining the responsible telehealth team data recorded on the telehealth operational data sets. After allowing for the exclusions described previously (Figure 1) 76 of the 716 telehealth patients were considered as Haxby practice patients (10.6%).

Methods

The methods used as those described in the main paper. Analysis of primary and secondary endpoints was performed using interaction tests for comparing the two sub-groups (Haxby patients and non-Haxby patients) and their individually matched control patients.

Results

There were some differences between the Haxby group and non-Haxby group patient characteristics (Table H1). Specifically the Haxby patients had a higher proportion of COPD patients (80.3% v 63.4% in the telehealth patients for each group) and this is also reflected in lower levels of diagnoses associated with heart failure in the Haxby group. Other differences were a higher history of injury in the Haxby group patients (27.6% v 19.4% in the telehealth patients) , lower average socioeconomic deprivation (index of multiple deprivation score 10.3 v 16.3 in the telehealth patients) and a lower prevalence of a diagnosis for mental health conditions (9.2% v 19.4% in the telehealth patients).

Although matched controls were chosen for overall balance the Haxby group and their matched controls had good within group balance with some minor differences in gender (38.2% in controls v 47.4% in telehealth patients), lower level of diabetes (22.4% in controls v 27.6% in telehealth patients) and emergency bed days in the previous year (12.6 in controls v 10.3 in telehealth patients).

The analysis of the primary endpoint of time for first emergency admission or death showed no significant difference between the Haxby and Non-Haxby groups (P for interaction 0.804). There were no significant differences in hazard ratios between the two groups for any of the secondary endpoints (Figure H1). The secondary difference-in-difference analysis (Figures H2a and H2b) showed similar results with the exception of non-elective bed days where there was some evidence that telehealth was associated with an additional increase in hospital bed days among the Haxby group when compared to effects among the non-Haxby group (P for interaction 0.023).

Discussion

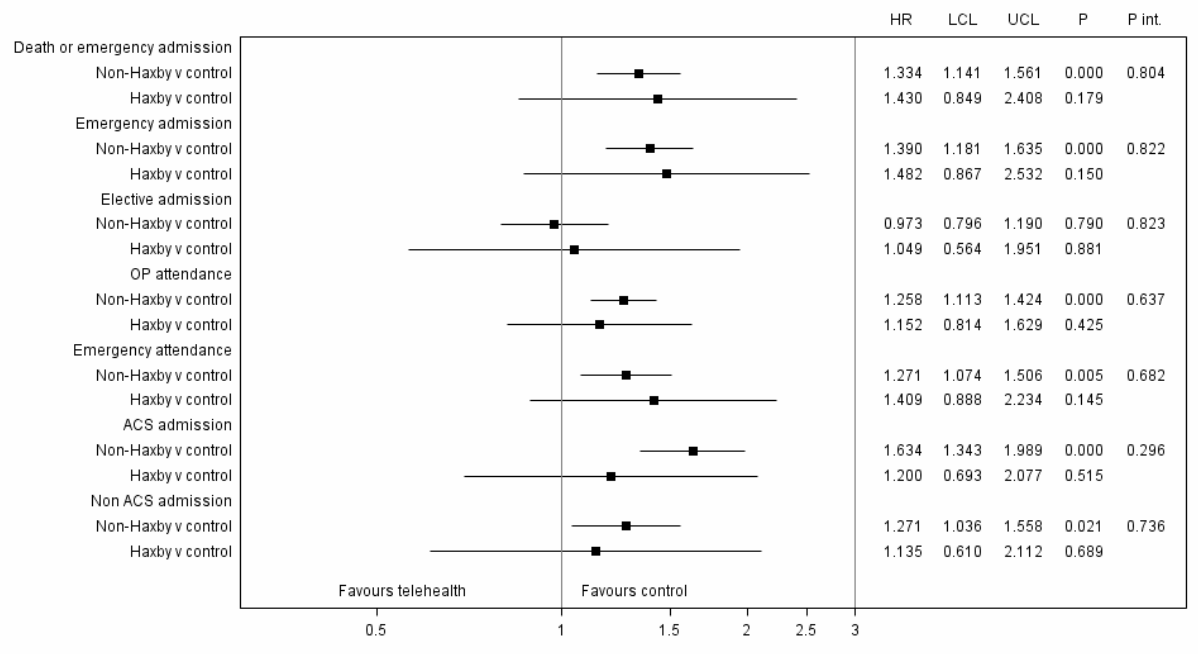
This results of this sub-group analysis showed that while the Haxby patient group differed from the non-Haxby group on a number of patient characteristics there were no significant differences between the two groups in the impact of telehealth on hospital admissions. The matched controls for both groups showed good balance which adds further validity to the results as the matching was optimised on overall balance. In addition the requirement that telehealth patients have a previous history of a hospital admission would have removed non-comparable Haxby patients treated only in primary care.

In conclusion the inclusion of Haxby telehealth patients as part of the telehealth programme as designed did not alter the findings from the main analysis.

Table H1: Patient characteristics. Data are proportion (%) or mean (standard deviation) unless otherwise stated.

	Haxby Controls	Haxby Telehealth	Non-Haxby Controls	Non-Haxby Telehealth
	(n=76)	(n=76)	(n=640)	(n=640)
Age (years)	72.9 (8.4)	72.6 (9.2)	72.6 (10.5)	72.7 (10.3)
Female (%)	38.2 (n=29)	47.4 (n=36)	42.3 (n=271)	42.2 (n=270)
Socioeconomic deprivation score*	12.0 (8.0)	10.3 (7.6)	15.5 (10.4)	16.3 (11.3)
Anaemia (%)	19.7 (n=15)	19.7 (n=15)	12.0 (n=77)	14.2 (n=91)
Angina (%)	15.8 (n=12)	18.4 (n=14)	23.3 (n=149)	24.8 (n=159)
Asthma (%)	18.4 (n=14)	14.5 (n=11)	12.5 (n=80)	14.5 (n=93)
Atrial fibrillation and flutter (%)	31.6 (n=24)	32.9 (n=25)	34.1 (n=218)	34.5 (n=221)
Cancer (%)	18.4 (n=14)	15.8 (n=12)	10.8 (n=69)	10.9 (n=70)
Cerebrovascular disease (%)	6.6 (n=5)	6.6 (n=5)	9.7 (n=62)	10.3 (n=66)
Congestive heart failure (%)	25.0 (n=19)	27.6 (n=21)	44.1 (n=282)	45.0 (n=288)
Chronic obstructive pulmonary disease (%)	75.0 (n=57)	80.3 (n=61)	60.8 (n=389)	63.4 (n=406)
Diabetes (%)	22.4 (n=17)	27.6 (n=21)	28.0 (n=179)	29.5 (n=189)
History of falls (%)	7.9 (n=6)	11.8 (n=9)	8.3 (n=53)	7.8 (n=50)
History of injury (%)	27.6 (n=21)	27.6 (n=21)	18.0 (n=115)	19.4 (n=124)
Hypertension (%)	50.0 (n=38)	43.4 (n=33)	55.5 (n=355)	57.2 (n=366)
Ischaemic heart failure (%)	31.6 (n=24)	34.2 (n=26)	39.5 (n=253)	40.9 (n=262)
Kidney failure (%)	10.5 (n=8)	11.8 (n=9)	10.3 (n=66)	11.7 (n=75)
Mental health condition (%)	7.9 (n=6)	9.2 (n=7)	19.2 (n=123)	19.4 (n=124)
Peripheral vascular disease (%)	17.1 (n=13)	22.4 (n=17)	12.8 (n=82)	13.6 (n=87)
Number of long term conditions	2.66 (1.55)	2.71 (1.53)	2.88 (1.51)	3.05 (1.6)
Predictive risk score	0.35 (0.23)	0.35 (0.23)	0.33 (0.20)	0.33 (0.20)
Emergency admissions (previous year)	1.14 (1.65)	1.51 (1.64)	1.31 (1.72)	1.32 (1.85)
Emergency admissions (previous month)	0.08 (0.32)	0.07 (0.3)	0.12 (0.37)	0.13 (0.4)
Elective admissions (previous year)	0.74 (1.18)	0.84 (1.3)	0.63 (1.11)	0.69 (1.4)
Elective admissions (previous month)	0.13 (0.38)	0.07 (0.25)	0.09 (0.31)	0.05 (0.23)
Outpatient attendances (previous year)	8.78 (9.04)	10.83 (10.72)	6.11 (6.46)	6.54 (6.63)
Outpatient attendances (previous month)	0.84 (1.42)	0.95 (1.65)	0.73 (1.49)	0.69 (1.15)
Emergency bed days (previous year)	12.61 (21.66)	10.32 (16.33)	12.1 (20.09)	12.23 (18.53)
Emergency bed days (previous year trimmed to 30 days))	8.99 (10.58)	8.24 (10.05)	9.16 (10.64)	9.58 (10.42)

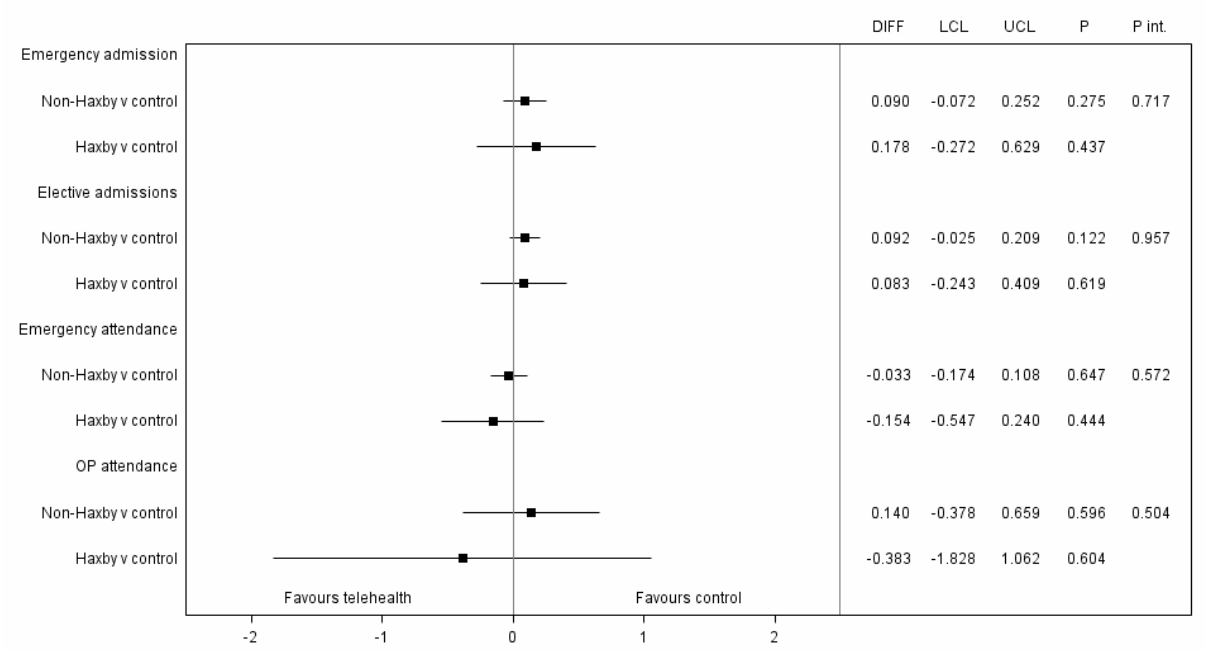
Figure H1: Time to event analysis of primary and secondary endpoints and 95% CIs (n=1432)



HR=hazard ratio from Cox regression analysis, LCL = lower 95% confidence interval for hazard ratio, UCL = upper 95% confidence interval for hazard ratio, P = p-value of the null hypothesis the hazard ratio is equal to one, P int. = p-value for the interaction test of a difference in the hazard ratios of Haxby v non-Haxby patients

Results adjusted for age (entered as a continuous variable), gender, socioeconomic deprivation decile, ethnicity, previous history of specific conditions (see list in Table 1), number of long term conditions, predictive risk score, emergency admissions (previous year), emergency admissions (previous month), elective admissions (previous year), elective admissions (previous month), outpatient attendances (previous year) and outpatient attendances (previous month).

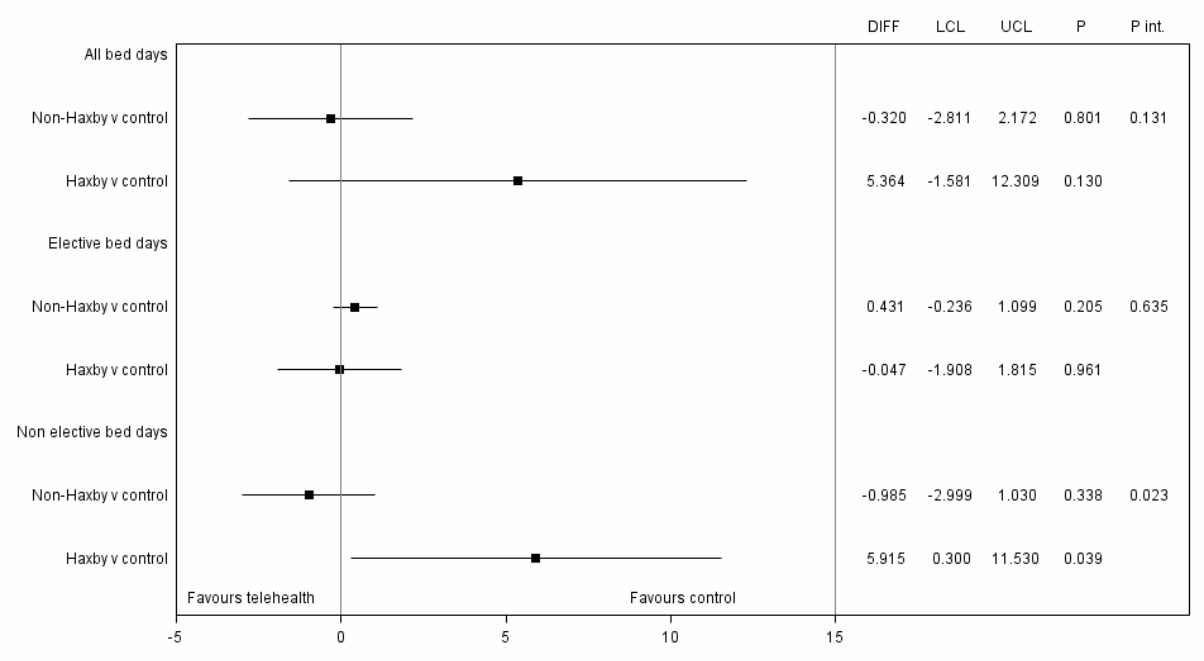
Figure H2: Secondary (difference-in-difference) analysis -Estimated differences in admission and attendance categories and 95% CIs (n=1307)



DIFF = difference in difference estimate from random effects linear regression analysis, LCL = lower 95% confidence interval for difference in difference estimate, UCL = upper 95% confidence interval for difference in difference estimate, P = p-value of the null hypothesis the difference is equal to zero, P int. = p-value for the interaction test of a difference in the differences of Haxby v non-Haxby patients

Results adjusted for age (entered as a continuous variable), gender, socioeconomic deprivation decile, ethnicity, previous history of specific conditions (anaemia, angina, asthma, atrial fibrillation and flutter, cancer, cerebrovascular disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes, falls, injury, hypertension, ischaemic heart failure, kidney failure, mental health condition, peripheral vascular disease), number of long term conditions, predictive risk score, emergency admissions (previous year), elective admissions (previous year) and outpatient attendances (previous year)

Figure H3: Secondary (difference-in-difference) analysis - Estimated differences in bed days and 95% CIs (n=1307)



DIFF = difference in difference estimate from random effects linear regression analysis, LCL = lower 95% confidence interval for difference in difference estimate, UCL = upper 95% confidence interval for difference in difference estimate, P = p-value of the null hypothesis the difference is equal to zero, P int. = p-value for the interaction test of a difference in the differences of Haxby v non-Haxby patients

Results adjusted for age (entered as a continuous variable), gender, socioeconomic deprivation decile, ethnicity, previous history of specific conditions (anaemia, angina, asthma, atrial fibrillation and flutter, cancer, cerebrovascular disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes, falls, injury, hypertension, ischaemic heart failure, kidney failure, mental health condition, peripheral vascular disease), number of long term conditions, predictive risk score, emergency admissions (previous year), elective admissions (previous year) and outpatient attendances (previous year)

Analysis of patient conditions at time of referral

Introduction

The intention of the telehealth programme was to target patients primarily with chronic heart failure (CHF) to be referred for telehealth. In addition to heart failure, patients with chronic obstructive pulmonary disease (COPD) were also enrolled into the programme. Over time the referral criteria in some locations was modified to include a small number of patients with diabetes. This sub-group analysis explores the relationship between the referring condition and the effect of telehealth on subsequent hospital usage.

Identification of patient conditions

The participant data supplied by Tunstall contained a description of the referring condition for 651 of the 716 telehealth patients included in the analysis. For the remaining 65 patients the estimated referring condition was inferred from the diagnosis history of the patients contained in their pre-enrolment hospital use history. In line with the programme design a diagnosis of CHF was prioritised over COPD with diabetes the final choice if there was no prior diagnosis of CHF or COPD.

Methods

The methods used as those described in the main paper. Analysis of primary and secondary endpoints was performed using interaction tests for comparing the three condition sub-groups (CHF, COPD and diabetes patients) and their individually matched control patients.

Results

Table C1 shows the patient characteristics for the three patient condition groups and their matched controls. The largest group of telehealth patients by condition at the time of referral is COPD patients (423, 59.1%) followed by CHF patients (259, 36.2%) and diabetes patients (34, 4.7%). As expected each group has a high prevalence of a previous diagnosis for each condition type. For CHF telehealth patients 86.9% had a previous hospitalisation for CHF, 93.9% of COPD patients had a previous admission for COPD and 100% of diabetes telehealth patients had a previous admission for diabetes.

Matched controls within each condition group showed good balance. Since there are only 34 diabetes patients there tends to be more differences between the telehealth patients and matched controls due to the small numbers. The two larger groups show no serious imbalances on any of the measured variables.

The analysis of the primary endpoint of time for first emergency admission or death showed no significant difference between the three referral condition groups (P for interaction 0.159). The results for CHF and COPD patients was very similar with the diabetes patients showing a much larger unfavourable impact of telehealth. However this is based on a small number of diabetes patients. There was a similar

trend in the secondary endpoints with no significant differences in hazard ratios between the groups (Figure C1).

The secondary difference-in-difference analysis (Figures C2a and C2b) showed similar results on all the measured outcomes. While a reduction in emergency admission and emergency attendances was observed for CHF patients they were not statistically significant (P=0.532 and P=0.183 respectively).

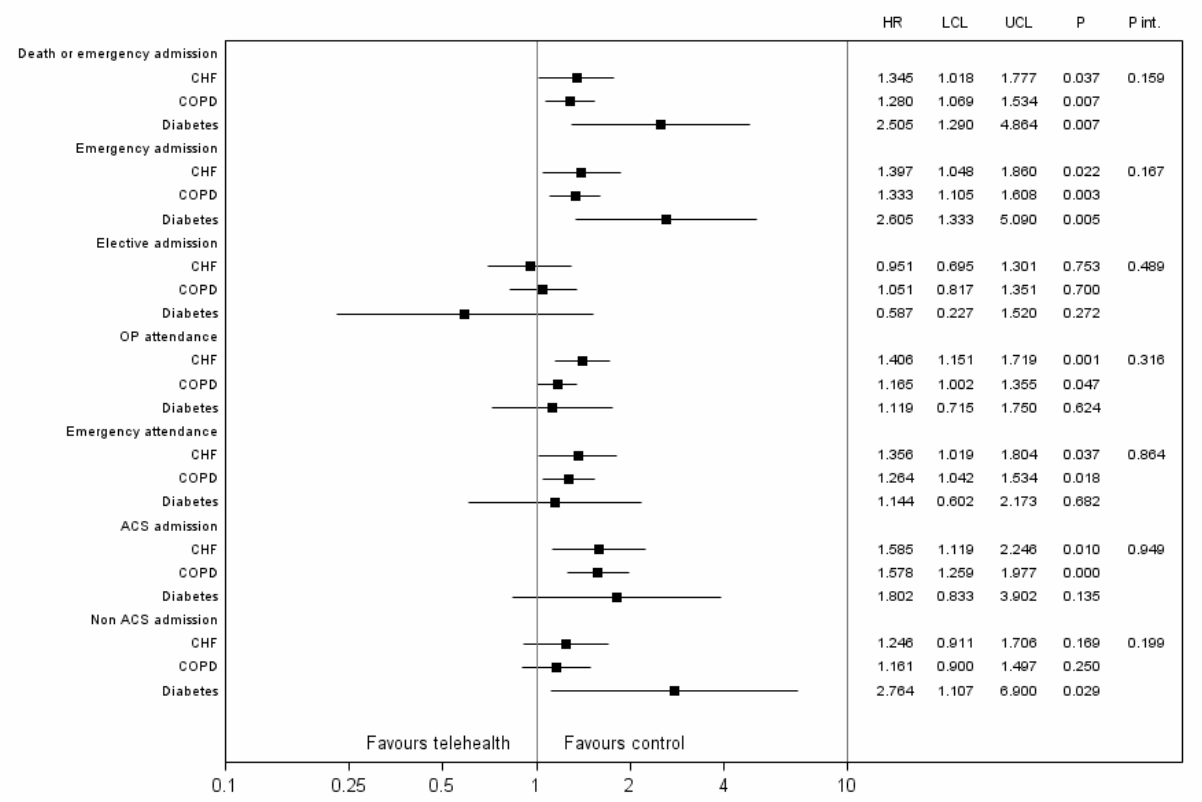
Discussion

This analysis examined the impact on telehealth based on the patient's referral condition. Whilst no statistical difference was observed between the conditions it appears based on the analysis of the primary endpoint and secondary endpoints that diabetes patients referred for telehealth benefitted less than CHF or COPD telehealth patients. Results for CHF and COPD were similar but there was a trend toward lower emergency admissions and emergency attendances for CHF patients which was not statistically significant.

Table C1: Patient characteristics. Data are proportion (%) or mean (standard deviation) unless otherwise stated.

	CHF Controls	CHF Telehealth	COPD Controls	COPD Telehealth	Diabetes Controls	Diabetes Telehealth
	(n=259)	(n=259)	(n=423)	(n=423)	(n=34)	(n=34)
Age (years)	73.3 (11.9)	72.9 (12.2)	72 (9.1)	72.3 (8.7)	75.4 (9.5)	75.8 (10.2)
Female (%)	34.4 (n=89)	29 (n=75)	46.6 (n=197)	49.6 (n=210)	41.2 (n=14)	61.8 (n=21)
Socioeconomic deprivation score*	14.3 (9.3)	16.2 (10.9)	15.5 (10.7)	15.5 (11.3)	16 (11.6)	13.4 (11)
Anaemia (%)	17.8 (n=46)	19.3 (n=50)	9.2 (n=39)	11.6 (n=49)	20.6 (n=7)	20.6 (n=7)
Angina (%)	31.7 (n=82)	32.4 (n=84)	16.3 (n=69)	18.2 (n=77)	29.4 (n=10)	35.3 (n=12)
Asthma (%)	10.0 (n=26)	11.2 (n=29)	15.4 (n=65)	16.3 (n=69)	8.8 (n=3)	17.6 (n=6)
Atrial fibrillation and flutter (%)	52.9 (n=137)	52.9 (n=137)	23.2 (n=98)	23.4 (n=99)	20.6 (n=7)	29.4 (n=10)
Cancer (%)	11.6 (n=30)	12.0 (n=31)	11.3 (n=48)	11.3 (n=48)	14.7 (n=5)	8.8 (n=3)
Cerebrovascular disease (%)	12.4 (n=32)	12.0 (n=31)	5.9 (n=25)	7.1 (n=30)	29.4 (n=10)	29.4 (n=10)
Congestive heart failure (%)	83.8 (n=217)	86.9 (n=225)	18.0 (n=76)	17.5 (n=74)	23.5 (n=8)	29.4 (n=10)
Chronic obstructive pulmonary disease (%)	25.5 (n=66)	25.1 (n=65)	88.7 (n=375)	93.9 (n=397)	14.7 (n=5)	14.7 (n=5)
Diabetes (%)	32.0 (n=83)	36.7 (n=95)	19.4 (n=82)	19.1 (n=81)	91.2 (n=31)	100.0 (n=34)
History of falls (%)	7.3 (n=19)	7.7 (n=20)	7.8 (n=33)	7.6 (n=32)	20.6 (n=7)	20.6 (n=7)
History of injury (%)	19.7 (n=51)	21.2 (n=55)	18.0 (n=76)	19.1 (n=81)	26.5 (n=9)	26.5 (n=9)
Hypertension (%)	69.5 (n=180)	70.7 (n=183)	44.4 (n=188)	45.2 (n=191)	73.5 (n=25)	73.5 (n=25)
Ischaemic heart failure (%)	56.4 (n=146)	58.3 (n=151)	27.2 (n=115)	29.1 (n=123)	47.1 (n=16)	41.2 (n=14)
Kidney failure (%)	15.4 (n=40)	19.7 (n=51)	6.6 (n=28)	6.6 (n=28)	17.6 (n=6)	14.7 (n=5)
Mental health condition (%)	13.5 (n=35)	14.7 (n=38)	21.5 (n=91)	21.0 (n=89)	8.8 (n=3)	11.8 (n=4)
Peripheral vascular disease (%)	13.1 (n=34)	16.6 (n=43)	12.3 (n=52)	13.0 (n=55)	26.5 (n=9)	17.6 (n=6)
Number of long term conditions	3.41 (1.44)	3.6 (1.52)	2.48 (1.43)	2.6 (1.50)	3.47 (1.62)	3.62 (1.78)
Predictive risk score	0.33 (0.20)	0.33 (0.21)	0.32 (0.20)	0.32 (0.20)	0.41 (0.26)	0.42 (0.26)
Emergency admissions (previous year)	1.31 (1.62)	1.31 (1.75)	1.27 (1.73)	1.32 (1.82)	1.38 (2.06)	1.91 (2.38)
Emergency admissions (previous month)	0.14 (0.39)	0.17 (0.45)	0.1 (0.35)	0.1 (0.33)	0.15 (0.44)	0.15 (0.56)
Elective admissions (previous year)	0.72 (1.16)	0.73 (1.29)	0.57 (1.01)	0.65 (1.25)	0.97 (1.83)	1.18 (2.94)
Elective admissions (previous month)	0.10 (0.33)	0.06 (0.23)	0.07 (0.27)	0.04 (0.21)	0.26 (0.62)	0.15 (0.44)
Outpatient attendances (previous year)	6.90 (7.16)	7.73 (7.93)	5.91 (6.09)	6.47 (6.40)	8.56 (11.15)	8.03 (11.24)
Outpatient attendances (previous month)	0.79 (1.52)	0.94 (1.41)	0.67 (1.44)	0.58 (1.02)	1.15 (1.79)	0.74 (1.54)
Emergency bed days (previous year)	13.03 (22.59)	13.92 (18.33)	11.24 (17.82)	10.61 (17.33)	16.68 (28.18)	15.12 (26.98)
Emergency bed days (previous year trimmed to 30 days))	9.60 (10.49)	10.97 (10.87)	8.76 (10.60)	8.47 (9.94)	10.26 (11.9)	9.88 (10.94)

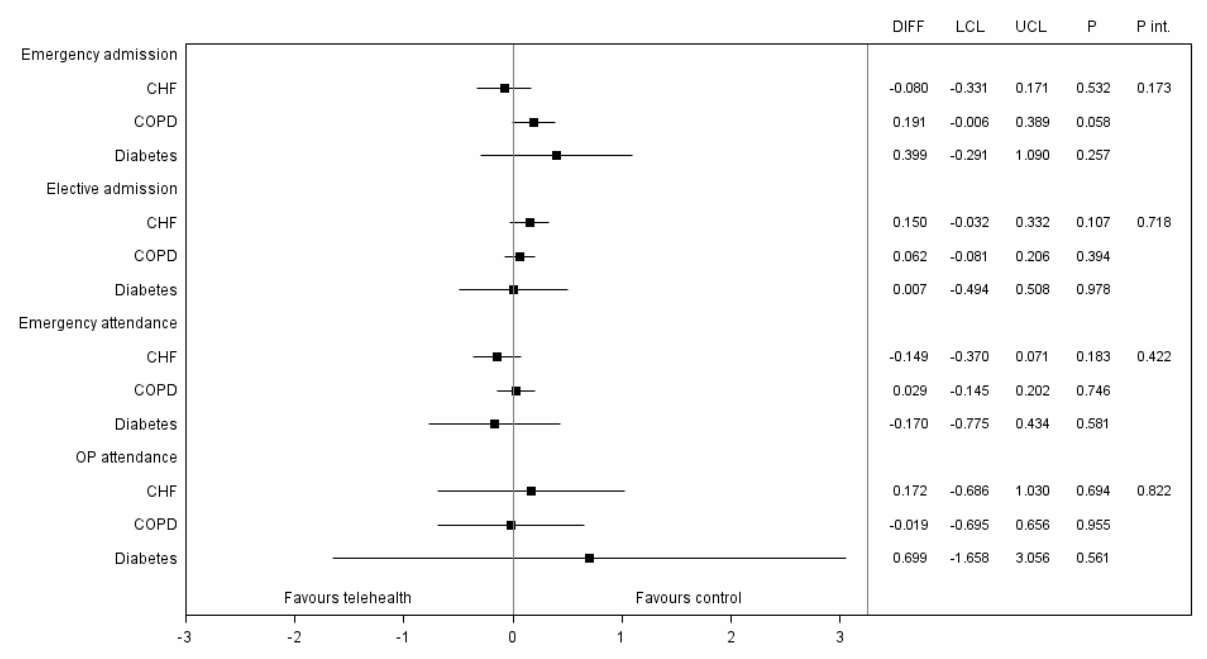
Figure C1: Time to event analysis of primary and secondary endpoints and 95% CIs (n=1432)



HR=hazard ratio from Cox regression analysis, LCL = lower 95% confidence interval for hazard ratio, UCL = upper 95% confidence interval for hazard ratio, P = p-value of the null hypothesis the hazard ratio is equal to one, P int. = p-value for the interaction test of a difference in the hazard ratios of patient referral conditions

Results adjusted for age (entered as a continuous variable), gender, socioeconomic deprivation decile, ethnicity, previous history of specific conditions (see list in Table 1), number of long term conditions, predictive risk score, emergency admissions (previous year), emergency admissions (previous month), elective admissions (previous year), elective admissions (previous month), outpatient attendances (previous year) and outpatient attendances (previous month).

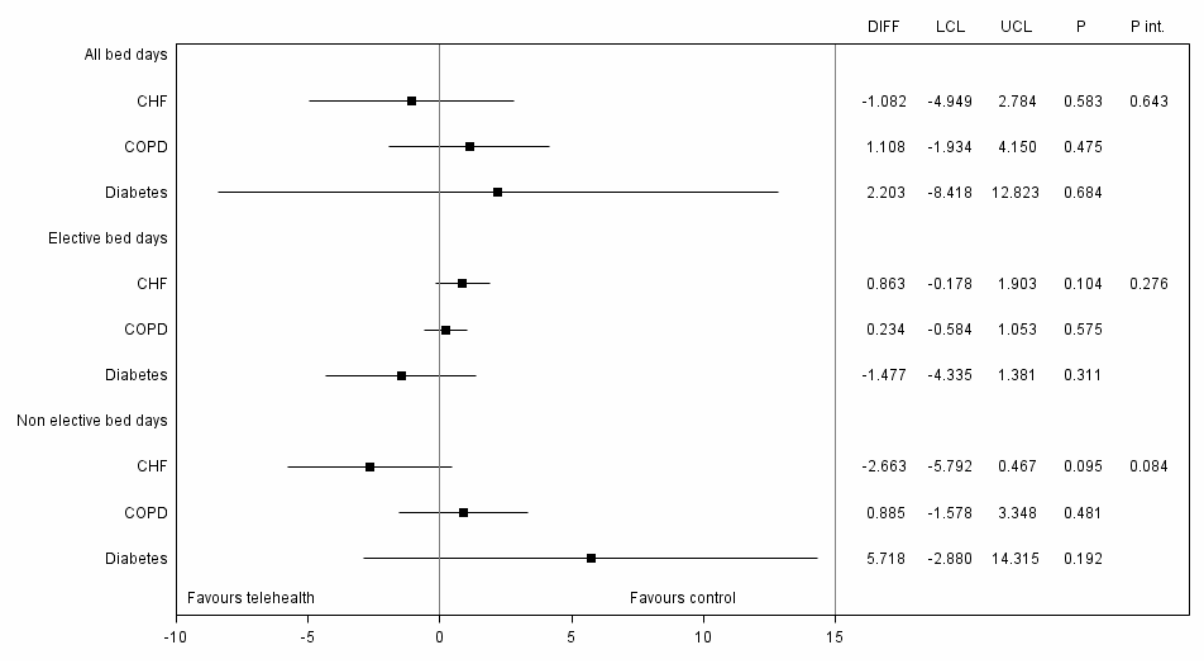
Figure C2: Secondary (difference-in-difference) analysis -Estimated differences in admission and attendance categories and 95% CIs (n=1307)



DIFF = difference in difference estimate from random effects linear regression analysis, LCL = lower 95% confidence interval for difference in difference estimate, UCL = upper 95% confidence interval for difference in difference estimate, P = p-value of the null hypothesis the difference is equal to zero, P int. = p-value for the interaction test of a difference in the differences of patient referral conditions

Results adjusted for age (entered as a continuous variable), gender, socioeconomic deprivation decile, ethnicity, previous history of specific conditions (anaemia, angina, asthma, atrial fibrillation and flutter, cancer, cerebrovascular disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes, falls, injury, hypertension, ischaemic heart failure, kidney failure, mental health condition, peripheral vascular disease), number of long term conditions, predictive risk score, emergency admissions (previous year), elective admissions (previous year) and outpatient attendances (previous year)

Figure C3: Secondary (difference-in-difference) analysis - Estimated differences in bed days and 95% CIs (n=1307)



DIFF = difference in difference estimate from random effects linear regression analysis, LCL = lower 95% confidence interval for difference in difference estimate, UCL = upper 95% confidence interval for difference in difference estimate, P = p-value of the null hypothesis the difference is equal to zero, P int. = p-value for the interaction test of a difference in the differences of the patient referral conditions

Results adjusted for age (entered as a continuous variable), gender, socioeconomic deprivation decile, ethnicity, previous history of specific conditions (anaemia, angina, asthma, atrial fibrillation and flutter, cancer, cerebrovascular disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes, falls, injury, hypertension, ischaemic heart failure, kidney failure, mental health condition, peripheral vascular disease), number of long term conditions, predictive risk score, emergency admissions (previous year), elective admissions (previous year) and outpatient attendances (previous year)

Analysis of patient dominant provider at time of referral

Introduction

The impact on acute hospital use can depend on the admissions policy and behaviour of each individual trust. This sub group analyses will examine if the impact of telehealth on secondary care is associated with the dominant provider for each patient at the time of their entry to the telehealth programme.

Identification of patient dominant provider

The hospital usage history of each telehealth patient was examined to identify the trust which recorded the most frequent emergency admissions prior to enrolment in the telehealth programme. This was then classified as the dominant provider for that patient. The sensitivity of this decision was checked by looking at the dominant provider in the post-enrolment period and cross-classifying the results. In the vast majority of cases the dominant provider was the same in both periods. The major dominant providers (NHS trust code) were identified as York Hospitals NHS Foundation Trust (RCB), Scarborough and North East Yorkshire Healthcare NHS Trust (RCC), Harrogate and District NHS Foundation Trust (RCD), Airedale NHS Foundation Trust (RCF) and South Tees NHS Trust (RTR). There were a small number of other trusts identified and this were categorised as 'other' due to the small number of patients in each trust.

Methods

The methods used as those described in the main paper. Analysis of primary and secondary endpoints was performed using interaction tests for comparing the six dominant provider trusts telehealth patients and their individually matched control patients.

Results

The provider with the largest number of telehealth patients was York Foundation Trust (FT) (327, 45.7%) followed by South Tees (92, 12.8%), Airedale FT (89, 12.4%), Harrogate FT (84, 11.7%) and Scarborough (76, 10.6%) (Table P1). There were a further 48 (6.7%) patients assigned to the other category (Table P1). There were some differences between the trusts notably Scarborough with higher levels of deprivation (socioeconomic score 25.7 v 14.7 when comparing telehealth patients with York FT), York FT tended to have more patients with a previous diagnosis for COPD (76.8% v 28.9% when comparing telehealth patients with Scarborough) and less CHF patients (31.5% v 76.3% when comparing telehealth patients again with Scarborough).

In general there was good balance between the matched controls and telehealth patients within each trust (Table P1). There were some differences but the smaller numbers in each of the trust sub-groups make some fluctuation understandable. When comparing balance in the largest sub-group, York FT, there were no variables were serious imbalance occurred.

The analysis of the primary endpoint of time for first emergency admission or death (Figure P1) showed no significant difference among the provider groups (P for interaction 0.523). There was no evidence of a favourable telehealth impact at any trust but York FT (P=0.016) and Harrogate FT (P=0.007) showed an unfavourable telehealth impact. There were no significant differences in hazard ratios between the groups for any of the secondary endpoints with no trust showing evidence of a favourable impact of telehealth.

The secondary difference-in-difference analysis (Figures P2a and P2b) again showed no significant differences among the providers. Examining some individual trusts there was some evidence that Scarborough had a reduction in emergency admissions (P=0.049) and emergency attendances (P=0.031) but this must be interpreted with caution due the small size of the groups.

Discussion

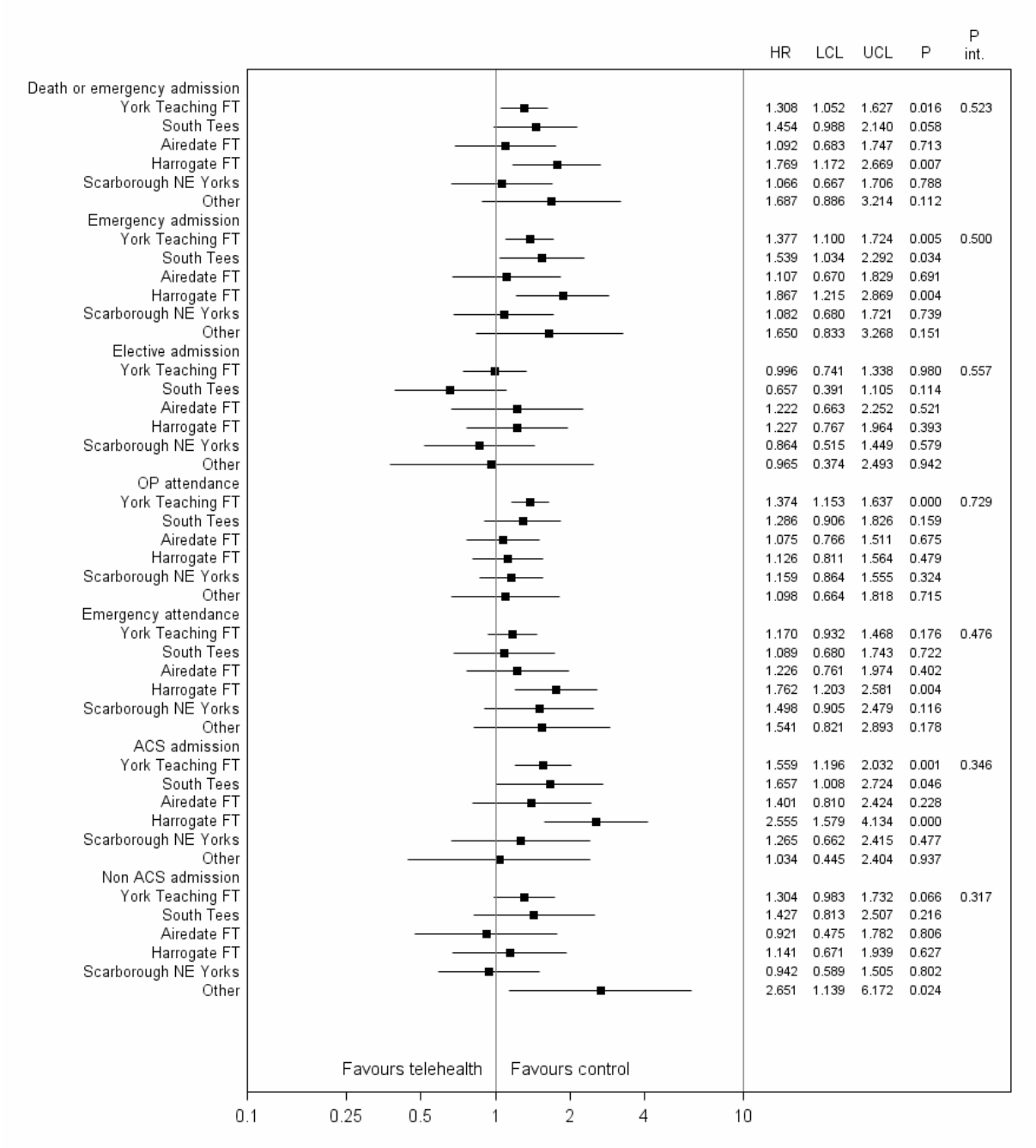
This results of this sub-group analysis showed that there were no statistically significant differences among the dominant providers in the telehealth programme. There were some individual trusts that showed a trend toward a favourable impact of telehealth on a few metrics but the overall impact was consistent among the providers. It follows that this finding would indicate that the majority of trusts in the programme area showed similar admission policies and behaviours in both the telehealth patients and matched controls.

Table P1: Patient characteristics. Data are proportion (%) or mean (standard deviation) unless otherwise stated.

	York FT Controls	York FT Telehealth	South Tees Controls	South Tees Telehealth	Scarborough NE Yorks Controls	Scarborough NE Yorks Telehealth	Harrogate FT Controls	Harrogate FT Telehealth	Airedale FT Controls	Airedale FT Telehealth	Other Controls	Other Telehealth
	(n=327)	(n=327)	(n=92)	(n=92)	(n=76)	(n=76)	(n=84)	(n=84)	(n=89)	(n=89)	(n=48)	(n=48)
Age (years)	72.7 (9.7)	72.7 (9.7)	71.7 (11.0)	71.6 (10.6)	73.6 (11.4)	73.4 (11.5)	71.5 (10.7)	71.3 (11.1)	74.4 (8.9)	74.8 (8.2)	71.8 (11.9)	72.1 (12)
Female (%)	43.4 (n=142)	48.3 (n=158)	31.5 (n=29)	32.6 (n=30)	48.7 (n=37)	32.9 (n=25)	45.2 (n=38)	45.2 (n=38)	42.7 (n=38)	43.8 (n=39)	33.3 (n=16)	33.3 (n=16)
Socioeconomic deprivation score*	14.1 (9.4)	14.7 (10.4)	14.8 (8.1)	14.0 (7.7)	20.3 (14.8)	25.7 (16)	15.5 (11.2)	16.1 (12.1)	15.0 (9.1)	12.7 (7.2)	13.4 (9)	14.4 (7.1)
Anaemia (%)	13.5 (n=44)	15.9 (n=52)	13.0 (n=12)	13.0 (n=12)	14.5 (n=11)	18.4 (n=14)	13.1 (n=11)	14.3 (n=12)	11.2 (n=10)	12.4 (n=11)	8.3 (n=4)	10.4 (n=5)
Angina (%)	20.5 (n=67)	20.5 (n=67)	23.9 (n=22)	29.3 (n=27)	26.3 (n=20)	30.3 (n=23)	27.4 (n=23)	27.4 (n=23)	18.0 (n=16)	22.5 (n=20)	27.1 (n=13)	27.1 (n=13)
Asthma (%)	12.8 (n=42)	12.8 (n=42)	8.7 (n=8)	8.7 (n=8)	14.5 (n=11)	18.4 (n=14)	16.7 (n=14)	19.0 (n=16)	16.9 (n=15)	18.0 (n=16)	8.3 (n=4)	16.7 (n=8)
Atrial fibrillation and flutter (%)	30.6 (n=100)	31.5 (n=103)	37.0 (n=34)	41.3 (n=38)	48.7 (n=37)	46.1 (n=35)	34.5 (n=29)	34.5 (n=29)	29.2 (n=26)	27.0 (n=24)	33.3 (n=16)	35.4 (n=17)
Cancer (%)	13.5 (n=44)	11.9 (n=39)	15.2 (n=14)	14.1 (n=13)	6.6 (n=5)	10.5 (n=8)	9.5 (n=8)	10.7 (n=9)	11.2 (n=10)	11.2 (n=10)	4.2 (n=2)	6.3 (n=3)
Cerebrovascular disease (%)	9.2 (n=30)	9.8 (n=32)	9.8 (n=9)	10.9 (n=10)	6.6 (n=5)	6.6 (n=5)	7.1 (n=6)	8.3 (n=7)	12.4 (n=11)	11.2 (n=10)	12.5 (n=6)	14.6 (n=7)
Congestive heart failure (%)	31.5 (n=103)	31.5 (n=103)	62.0 (n=57)	63.0 (n=58)	72.4 (n=55)	76.3 (n=58)	41.7 (n=35)	44.0 (n=37)	32.6 (n=29)	33.7 (n=30)	45.8 (n=22)	47.9 (n=23)
Chronic obstructive pulmonary disease (%)	72.5 (n=237)	76.8 (n=251)	53.3 (n=49)	52.2 (n=48)	27.6 (n=21)	28.9 (n=22)	63.1 (n=53)	66.7 (n=56)	70.8 (n=63)	71.9 (n=64)	47.9 (n=23)	54.2 (n=26)
Diabetes (%)	25.4 (n=83)	27.8 (n=91)	34.8 (n=32)	32.6 (n=30)	28.9 (n=22)	36.8 (n=28)	22.6 (n=19)	31.0 (n=26)	31.5 (n=28)	28.1 (n=25)	25.0 (n=12)	20.8 (n=10)
History of falls (%)	8.0 (n=26)	10.1 (n=33)	8.7 (n=8)	8.7 (n=8)	7.9 (n=6)	2.6 (n=2)	13.1 (n=11)	11.9 (n=10)	6.7 (n=6)	3.4 (n=3)	4.2 (n=2)	6.3 (n=3)
History of injury (%)	20.2 (n=66)	22.3 (n=73)	25.0 (n=23)	25.0 (n=23)	18.4 (n=14)	14.5 (n=11)	20.2 (n=17)	20.2 (n=17)	13.5 (n=12)	14.6 (n=13)	8.3 (n=4)	16.7 (n=8)
Hypertension (%)	46.5 (n=152)	45.9 (n=150)	59.8 (n=55)	66.3 (n=61)	61.8 (n=47)	64.5 (n=49)	59.5 (n=50)	60.7 (n=51)	66.3 (n=59)	65.2 (n=58)	62.5 (n=30)	62.5 (n=30)
Ischaemic heart failure (%)	33.0 (n=108)	36.4 (n=119)	51.1 (n=47)	54.3 (n=50)	42.1 (n=32)	40.8 (n=31)	45.2 (n=38)	41.7 (n=35)	38.2 (n=34)	38.2 (n=34)	37.5 (n=18)	39.6 (n=19)
Kidney failure (%)	10.4 (n=34)	11.0 (n=36)	18.5 (n=17)	18.5 (n=17)	10.5 (n=8)	11.8 (n=9)	6.0 (n=5)	9.5 (n=8)	7.9 (n=7)	11.2 (n=10)	6.3 (n=3)	8.3 (n=4)
Mental health condition (%)	16.5 (n=54)	17.4 (n=57)	19.6 (n=18)	17.4 (n=16)	17.1 (n=13)	17.1 (n=13)	14.3 (n=12)	14.3 (n=12)	21.3 (n=19)	24.7 (n=22)	27.1 (n=13)	22.9 (n=11)
Peripheral vascular disease (%)	12.2 (n=40)	16.5 (n=54)	10.9 (n=10)	9.8 (n=9)	14.5 (n=11)	13.2 (n=10)	14.3 (n=12)	14.3 (n=12)	16.9 (n=15)	11.2 (n=10)	14.6 (n=7)	18.8 (n=9)
Number of long term conditions	2.69 (1.52)	2.8 (1.56)	3.28 (1.53)	3.42 (1.59)	2.97 (1.35)	3.21 (1.47)	2.92 (1.61)	3.14 (1.76)	2.99 (1.51)	3.07 (1.54)	2.73 (1.36)	3.00 (1.65)
Predictive risk score	0.35 (0.22)	0.35 (0.22)	0.33 (0.18)	0.33 (0.18)	0.32 (0.19)	0.31 (0.18)	0.33 (0.22)	0.33 (0.22)	0.31 (0.19)	0.31 (0.2)	0.28 (0.18)	0.28 (0.18)

Emergency admissions (previous year)	1.28 (1.66)	1.39 (1.78)	1.23 (1.60)	1.18 (1.74)	1.50 (1.63)	1.63 (1.55)	1.6 (2.23)	1.7 (2.54)	1.02 (1.59)	0.91 (1.61)	1.13 (1.50)	1.08 (1.44)
Emergency admissions (previous month)	0.10 (0.34)	0.11 (0.35)	0.09 (0.32)	0.09 (0.35)	0.25 (0.52)	0.33 (0.64)	0.14 (0.41)	0.12 (0.33)	0.10 (0.34)	0.10 (0.34)	0.06 (0.24)	0.08 (0.28)
Elective admissions (previous year)	0.69 (1.24)	0.70 (1.31)	0.61 (0.88)	0.86 (1.62)	0.42 (0.80)	0.54 (0.92)	0.56 (0.87)	0.58 (1.04)	0.79 (1.40)	0.87 (2.02)	0.60 (0.84)	0.60 (1.09)
Elective admissions (previous month)	0.09 (0.31)	0.06 (0.24)	0.04 (0.21)	0.07 (0.25)	0.03 (0.16)	0.05 (0.22)	0.14 (0.38)	0.04 (0.19)	0.16 (0.47)	0.04 (0.26)	0.06 (0.24)	0.04 (0.20)
Outpatient attendances (previous year)	6.96 (6.67)	7.95 (7.32)	8.40 (9.23)	10.88 (8.29)	4.80 (5.64)	2.84 (5.23)	5.38 (4.35)	6.42 (5.53)	4.57 (4.54)	4.28 (4.31)	6.40 (9.48)	5.75 (9.55)
Outpatient attendances (previous month)	0.78 (1.6)	0.78 (1.26)	1.08 (2.07)	1.17 (1.67)	0.53 (0.96)	0.42 (0.75)	0.64 (1.06)	0.55 (0.88)	0.48 (0.84)	0.45 (0.78)	0.79 (1.53)	0.71 (1.38)
Emergency bed days (previous year)	13.04 (20.51)	11.03 (16.9)	14.7 (28.83)	13.79 (17.48)	10.74 (13.00)	11.97 (12.63)	13.46 (21.46)	14.69 (25.32)	8.72 (14)	12.19 (20.3)	7.48 (13.8)	10.46 (18.44)
Emergency bed days (previous year trimmed to 30 days))	9.75 (10.94)	8.88 (10.33)	9.36 (11.02)	11.04 (11.09)	9.53 (10.01)	10.82 (9.47)	9.75 (10.8)	10.05 (10.63)	7.44 (9.74)	9.12 (10.49)	6.02 (9.43)	7.5 (9.97)

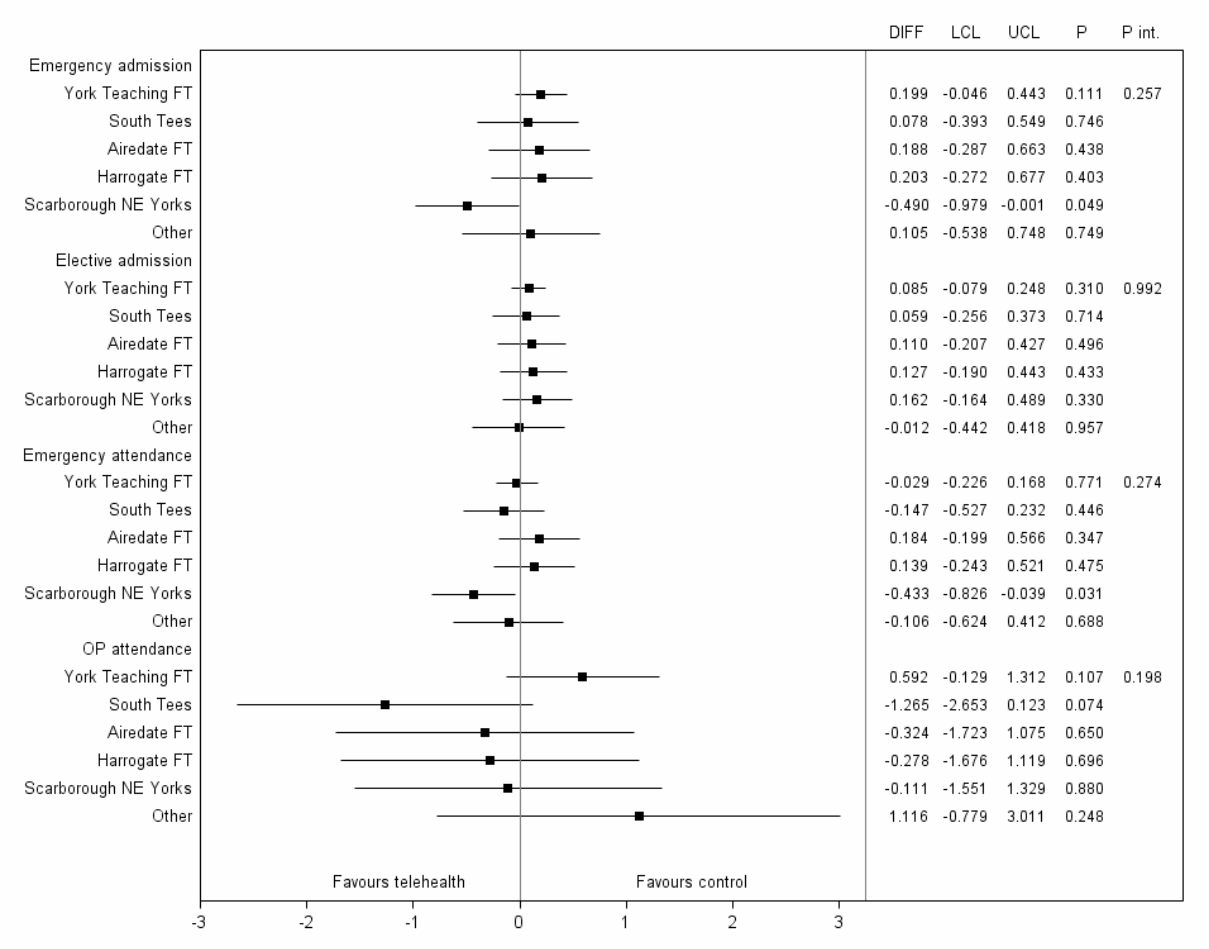
Figure P1: Time to event analysis of primary and secondary endpoints and 95% CIs (n=1432)



HR=hazard ratio from Cox regression analysis, LCL = lower 95% confidence interval for hazard ratio, UCL = upper 95% confidence interval for hazard ratio, P = p-value of the null hypothesis the hazard ratio is equal to one, P int. = p-value for the interaction test of a difference in the hazard ratios of patient dominant provider

Results adjusted for age (entered as a continuous variable), gender, socioeconomic deprivation decile, ethnicity, previous history of specific conditions (see list in Table 1), number of long term conditions, predictive risk score, emergency admissions (previous year), emergency admissions (previous month), elective admissions (previous year), elective admissions (previous month), outpatient attendances (previous year) and outpatient attendances (previous month).

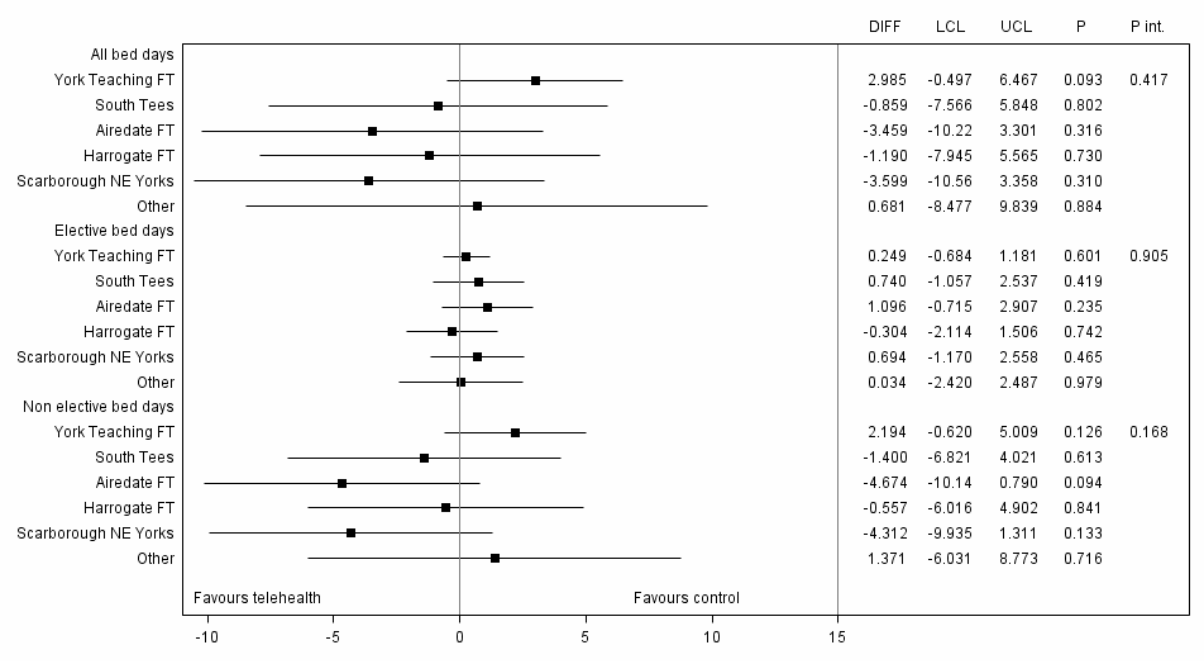
Figure P2: Secondary difference–in-difference analysis – admissions and attendances endpoints and 95% CIs (n=1307)



DIFF = difference in difference estimate from random effects linear regression analysis, LCL = lower 95% confidence interval for difference in difference estimate, UCL = upper 95% confidence interval for difference in difference estimate, P = p-value of the null hypothesis the difference is equal to zero, P int. = p-value for the interaction test of a difference in the differences of patient dominant provider

Results adjusted for age (entered as a continuous variable), gender, socioeconomic deprivation decile, ethnicity, previous history of specific conditions (anaemia, angina, asthma, atrial fibrillation and flutter, cancer, cerebrovascular disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes, falls, injury, hypertension, ischaemic heart failure, kidney failure, mental health condition, peripheral vascular disease), number of long term conditions, predictive risk score, emergency admissions (previous year), elective admissions (previous year) and outpatient attendances (previous year)

Figure P3: Secondary (difference-in-difference) analysis - Estimated differences in bed days and 95% CIs (n=1307)



DIFF = difference in difference estimate from random effects linear regression analysis, LCL = lower 95% confidence interval for difference in difference estimate, UCL = upper 95% confidence interval for difference in difference estimate, P = p-value of the null hypothesis the difference is equal to zero, P int. = p-value for the interaction test of a difference in the differences of the patient dominant provider

Results adjusted for age (entered as a continuous variable), gender, socioeconomic deprivation decile, ethnicity, previous history of specific conditions (anaemia, angina, asthma, atrial fibrillation and flutter, cancer, cerebrovascular disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes, falls, injury, hypertension, ischaemic heart failure, kidney failure, mental health condition, peripheral vascular disease), number of long term conditions, predictive risk score, emergency admissions (previous year), elective admissions (previous year) and outpatient attendances (previous year)