

# BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email [info.bmjopen@bmj.com](mailto:info.bmjopen@bmj.com)

# BMJ Open

## Should I stay or should I go? A retrospective propensity score matched analysis using administrative data of hospital-at-home for older people

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-023350
Article Type:	Research
Date Submitted by the Author:	04-Apr-2018
Complete List of Authors:	Tsiachristas, Apostolos; University of Oxford, Health Economics Research Centre, Nuffield Department of Population Health Ellis, Graham; Monklands Hospital, NHS Lanarkshire Buchanan, Scott; Information Services Division, National Services Scotland Langhorne, Peter; University of Glasgow, Institute of Cardiovascular and Medical Sciences Stott, David; Institute of Cardiovascular and Medical Sciences, University of Glasgow, Geriatric Medicine Shepperd, S; University of Oxford, Nuffield Department of Population Health
Keywords:	hospital-at-home, admission avoidance, intermediate care, costs, mortality, UK

SCHOLARONE™  
Manuscripts

# Should I stay or should I go? A retrospective propensity score matched analysis using administrative data of hospital-at-home for older people

Apostolos Tsiachristas<sup>1</sup>, Graham Ellis<sup>2</sup>, Scott Buchanan<sup>3</sup>, Peter Langhorne<sup>4</sup>, David Stott<sup>4</sup>, Sasha Shepperd<sup>1</sup>.

<sup>1</sup> Nuffield Department of Population Health, University of Oxford, Oxford, UK

<sup>2</sup> Monklands Hospital, NHS Lanarkshire, Glasgow, UK

<sup>3</sup> Information Services Division, National Services Scotland, Edinburgh, UK

<sup>4</sup> Institute of Cardiovascular and Medical Sciences, University of Glasgow, Glasgow, UK

Word Count: 4783

Correspondence to: Apostolos Tsiachristas, Health Economics Research Centre, Nuffield Department of Population Health, Richard Doll building, Old Road Campus, OX3 7LF, Oxford, UK; Tel: +44(0)1865 289470; email: [apostolos.tsiachristas@dph.ox.ac.uk](mailto:apostolos.tsiachristas@dph.ox.ac.uk)

## Abstract

Objectives: To compare the characteristics of populations admitted to hospital-at-home services with the population admitted to hospital and assess the association of these services with healthcare costs and mortality.

Design: In a retrospective observational cohort study of patient level data we used propensity score matching in combination with regression analysis.

Participants: Patients aged 65 years and older who were admitted with similar diagnoses to either hospital-at-home or hospital at the same period.

Interventions: Three geriatrician-led admission avoidance hospital-at-home services.

Main outcome measures: Healthcare costs and mortality.

Results: Patients in hospital-at-home were older and more socioeconomically disadvantaged, had higher rates of previous hospitalization, and there was a greater proportion of women and people with several chronic conditions compared with the population admitted to hospital. The cost of providing hospital-at-home varied between the three sites from £628 to £2928 per admission. Hospital-at-home was associated to 18% lower costs during the follow-up period in site one (ratio of means 0.82; 95%CI: 0.76 to 0.89). Limiting the analysis to costs during the 6 months following index discharge, patients in the hospital-at-home cohorts had 27% higher costs (ratio of means 1.27; 95%CI: 1.14 to 1.41) in site one, 9% (ratio of means 1.09; 95%CI: 0.95 to 1.24) and 70% in site three (ratio of means 1.70; 95%CI: 1.40 to 2.07) compared with patients in the control cohorts. Admission to hospital-at-home was associated with an increased risk of death during the follow-up period in all three sites (1.09, 95%CI: 1.00 to 1.19 site one; 1.29, 95%CI 1.15 to 1.44 site two; 1.27, 95%CI 1.06 to 1.54 site three).

Conclusions: It is important to identify robust measures for admission to hospital-at-home and collect data on subsequent use of health, social, and informal care following admission to hospital-at-home or hospital to be used in a clinical trial.

**Strengths and limitations of the study**

- The study used a large dataset from three of the largest Health Boards in Scotland.
- The quasi-experimental study design has allowed inferences from real world evidence.
- Various sensitivity analyses helped to address uncertainty in the results.
- The major limitation of this type of non-randomised comparison is residual confounding.
- The data lacked of quality of life measurements as well as use of community and informal care.

## Introduction

Organising health systems to optimise the health outcomes of older people and contain costs is a priority as populations around the world age, and the demand for healthcare continues to rise. Despite a global policy emphasis on 'care closer to home'<sup>1</sup> and initiatives that seek to ease demand for hospital based healthcare, efforts to innovate and deliver healthcare services that provide an alternative to hospital admission for older people have been piecemeal and often lack a health system perspective. A lack of evidence to support decision-making has contributed to this. Avoiding admission to hospital by providing acute healthcare in people's homes, often as a hospital outreach service, is one of the more popular service innovations and yet there is uncertainty around the effectiveness and cost-effectiveness of this form of care.<sup>2</sup>

The use of administrative data to evaluate service delivery interventions has the potential to provide a simple and efficient mechanism to provide real-world evidence about policy relevant service innovations, and embed evaluation into local decision-making. However, previous experience of using routine data in this area of research has been of mixed success due to a limited set of variables, missing data and the complexity of policy relevant questions that often require a broad and longer term perspective.<sup>3</sup> Administrative healthcare data collected in Scotland is unique in that it is population based, with little missing data. The aim of this study was to use these data to compare the characteristics of populations from three Health Boards who used a geriatrician-led hospital-at-home service with the population who received hospital care, and to assess the impact of these services on healthcare costs and mortality.

### Box 1 Description of each service

#### Hospital-at-home

The three hospital-at-home services are broadly similar, capacity ranged between 24 to 60 beds for the period of the analysis. Each is a geriatrician-led service that is supported by nurses (sometimes nurse practitioners) and therapy practitioners for the initial assessment; geriatricians and the multidisciplinary team review patients in their homes and meet daily (a virtual ward round) to discuss patient cases and agree actions. Rehabilitation is available within the existing team with onward referral to community rehabilitation as required, and in one site rehabilitation is accessed through a parallel community rehabilitation services. Out of hours emergency cover is provided by primary care out-of-hours. Patients are referred to the service from GPs, sometimes through a central referral number or via step down from the acute hospital. The service offers access to diagnostics such as radiology, and intravenous fluids, antibiotics and oxygen. Cases are discussed daily with the multidisciplinary team at the virtual ward round and daily management plans agreed. In one site there is close working with the day hospital where patients can be referred for follow up or for investigations. Patients access investigations and treatment with the same speed as inpatients. The services support intravenous therapies in the home.

#### Hospital

The provision of hospital based acute health services varied among the sites; in one site there were three district general hospitals (1,653 beds) that provide acute health services to a mainly urban population of 652,230, with a total of 1,653 beds; in site two a hospital (550 beds) provides acute healthcare to a population of 180,130; and in site three there are two district general hospitals (825 beds) that provide healthcare to a population of 358,900, and acute admissions are via one of the hospitals.

## Methods

### Setting

We used patient level data collected by three of the fourteen Scottish Health Boards of all patients aged 64 years and older, and who were admitted (referred to as the index admission) to either geriatrician-led admission avoidance hospital-at-home or inpatient hospital between August 2014 and December 2015 (17 months) in site one and site two, and between January 2015 and December 2016 (24 months) in site three. These services are commissioned by integrated health and social care boards that cover a population of almost 1.5 million in urban and rural areas. The Information Service Division (ISD), part of NHS Scotland, de-identified, cleaned and linked individual patient records to derive activity and costs related to periods before and after the index admissions. We obtained signed release forms from each Board's Caldicott guardian, and followed the ISD data sharing agreement.

### Intervention

The three service models of hospital-at-home provided an admission avoidance function that provided an alternative to inpatient hospital care, and had similar structures and functions; the main differences were in the capacity of the services and the organisation of services for rehabilitation. (Box 1)

### Data sources

Data were available for each person for two years prior to their index admission, and from the point of their index admission to six months after index discharge from hospital-at-home or hospital. Box 2 presents a full list of all variables included in the dataset. Figure 1 provides schematic examples of the differing calendar time periods studied before and after index admission for people

#### Box 2. List of variables included in the dataset

Costs of accidents and emergency attendances,  
 Costs of acute day cases,  
 Costs of acute elective hospitalisation,  
 Costs of acute non-elective hospitalisation,  
 Costs of geriatric wards,  
 Costs of mental health wards,  
 Costs of outpatient visits,  
 Costs of prescribed medication,  
 Costs of (re)admission to hospital-at-home.  
 Primary ICD-10 codes on index discharge,  
 Secondary ICD-10 codes on index discharge,  
 Length of stay of the index admission,  
 Age on index admission,  
 Gender,  
 Scottish Index of Multiple Deprivation (SIMD), 1 (most deprived) to 10 (most affluent)  
 Long-term conditions,  
 Date of death (if applicable),  
 Based on ICD-10 codes:  
 Cardiovascular disease (CVD) (I60-I69, G45)  
 Chronic obstructive pulmonary disorder (COPD) (J41-J44, J47),  
 Dementia (F00-F03, F05.1),  
 Diabetes (E10-E14),  
 Coronary heart disease (CHD, ICD10: I20-I25),  
 Heart failure (I500, I501, I509),  
 Renal failure (N03, N18, N19, I12, I13),  
 Epilepsy (G40, G41),  
 Asthma (J45, J46),  
 Atrial fibrillation (I48, MS, G35),  
 Cancer (C00-C97),  
 Arthritis (M05, M19, M45, M47, M460-M462, M464, M468, M469),  
 Parkinson's (G20-G22),  
 Chronic liver disease (K711, K713, K714, K717, K754),  
 Congenital problems (Q00-Q99),  
 Diseases of blood and blood forming organs (D50-D89),  
 Other diseases of the digestive system (K00-K122, K130-K839, K85X, K860-K93),  
 Other endocrine metabolic diseases (E00-E07, E15-E35, E70-E90)  
 Admitted to HAH or hospital.

1  
2  
3 admitted between August 2014 and December 2015 to hospital-at-home (Patients A and B) or  
4 hospital (Patients C and D) in site one. As this illustrates, the maximum follow-up period for each  
5 patient consisted of the period between index admission and index discharge and 6 months after  
6 index discharge. The data were collected via the data systems used in hospitals to collect patient  
7 data. Hospital-at-home activity data is submitted to ISD from the local systems of the three sites. The  
8 following data sets are included acute inpatient, geriatric long stay and day case, mental health  
9 admissions, outpatient appointments accident and emergency attendances, community prescribing  
10 and NRS death registrations.  
11  
12  
13  
14  
15  
16  
17

18 Figure 1. Illustration of obtained data from site one  
19  
20  
21

### 22 *Selection of patients in the hospital-at-home and control cohorts*

23  
24 We included patients aged 65 years and older, and who were classified as an unscheduled admission  
25 to general or geriatric medicine. In the control cohort, we excluded those with a diagnosis that  
26 would not be eligible for management through hospital-at-home; these exclusions included acute  
27 intracerebral crisis (intracerebral infections, trauma or haemorrhage), stroke and related codes,  
28 acute coronary syndromes and myocardial infarction, surgical emergencies including vascular,  
29 urological, gynaecological and general surgical presentations, orthopaedic diagnosis of fractures and  
30 trauma, cardiothoracic diagnoses, poisoning and complications of surgery. We also excluded from  
31 the control group those who had a diagnosis (i.e. primary and secondary ICD-10 code) that was not  
32 observed in any of the hospital-at-home admissions in each site (1081 patients in site one, 1405 in  
33 site two and in 451 in site three) (Figure 2). Each patient was counted as a single episode of  
34 healthcare.  
35  
36  
37  
38  
39  
40  
41

### 42 *Intervention costs*

43  
44 We collected data on the costs of hospital-at-home using a template derived from the Cost-It tool of  
45 the World Health Organisation.<sup>4</sup> The cost categories included staff, training, transport, information  
46 and communication, clinical materials/equipment, support services, laboratory services, diagnostics,  
47 overheads and other costs. Clinician managers supported by finance staff in the three Health Boards  
48 completed this template based on the actual spending for the hospital-at-home service for the time  
49 periods covered by the ISD data. The cost per hospital-at-home admission was calculated by dividing  
50 the total costs of the hospital-at-home service by the total number of hospital-at-home admissions  
51 during the same period.  
52  
53  
54  
55  
56  
57  
58  
59  
60



### *Statistical analysis*

We used an iterative approach to the analysis, starting with a description of the two cohorts (i.e. those admitted to hospital-at-home and those admitted to hospital) for each Health Board. We calculated means, standard errors, and frequencies to describe differences in patient characteristics at index admission and tested differences using Mann-Whitney test for continuous variables and Chi-square test for categorical variables. We also estimated the mean differences in resource utilisation costs (with bootstrapped standard errors) and the unadjusted relative risk of mortality between the two cohorts for each Health Board.

Further, we investigated the association of being admitted to hospital-at-home or hospital with mortality and cost over a minimum follow-up period of six months. To do this, we followed the Medical Research Council guidelines on performing natural experiments and scientific literature to adopt a step-wise strategy to select the propensity score matching (PSM) technique that most reduced observed confounding between the two cohorts in each Health Board.<sup>5-8</sup> First, we included all possible confounding variables available in the dataset (see Box 2 and Figure 2), and considered that the inclusion of covariates not associated with the treatment assignment would have little influence in the propensity score model.<sup>5</sup> Second, we matched the two cohorts in each site using a range of the most commonly used PSM techniques; these included Mahalanobis, 1-to-1, K-to-1, kernel, local linear regression, spline, and inverse probability weighting techniques. Second, the performance of each PSM technique on covariate balancing was assessed based on the mean and median percentage standardised bias as well as Rubin's B (the absolute standardized difference of the means of the linear index of the propensity score in the treated and (matched) non-treated group) and Rubin's R (the ratio of treated to (matched) non-treated variances of the propensity score index). Following Rubin's (2001) recommendation, we considered B less than 25 and R between 0.5 and 2 to indicate sufficient balance.<sup>9</sup> Third, we chose the PSM technique that had the lowest values on these performance indicators in each of the three Health Boards. We matched the two cohorts in each Health Board by socio-demographic characteristics (i.e. age, gender, socio-economic status), diagnosis code (i.e. primary and secondary ICD-10 code) of index admission, morbidity (i.e. type of long-term condition, mortality during follow-up (for the analysis of cost), 2-year costs prior to the index admission (by cost category as listed in Box 1), and date of index admission (to account for seasonal trends).

We performed a doubly robust estimation to further reduce confounding by using a regression analysis after performing the most suitable PSM technique and including the confounding variables listed above as covariates.<sup>10</sup> In the regression, we used generalised linear regression models (GLMs) with gamma distribution and log link to investigate the association of hospital-at-home with total

1  
2  
3 costs during the follow-up period, and total costs in 6 months following index discharge. We also  
4 used GLMs with Poisson distribution and log link to estimate the relative risk of mortality. Robust  
5 standard errors were specified in all regression models. We calculated Kaplan-Meier survival curves,  
6 with and without using the weights from the PSM, and used log-rank tests to test the equality of the  
7 survival functions. There were few missing observations in the dataset and thus, complete case  
8 analysis was performed.  
9

### 10 11 12 *Subgroup analysis*

13  
14 We conducted a sub-group analysis, running the same regression models used in the main analysis,  
15 to investigate the association of hospital-at-home services with costs and mortality for the  
16 population who had a diagnosis of dementia. We considered this population to be important due to  
17 their complex healthcare needs, and the increasing prevalence of dementia.<sup>11 12</sup> In a second  
18 subgroup analysis, we excluded patients who died during the follow-up period and investigated the  
19 association of hospital-at-home with costs. In both subgroup analyses, propensity score matching  
20 was performed to match sub-cohorts in each site.  
21  
22

### 23 24 25 *Sensitivity analysis*

26  
27 In a univariate sensitivity analysis, we reduced and increased the intervention cost of admission  
28 avoidance hospital-at-home by 50%, as there are no standard unit costs to benchmark these types of  
29 services and we were concerned that costs for these services may vary due to economies of scale,  
30 size, experience, setting, human resource capacity, and error. This sensitivity analysis was expected  
31 to impact the costs during index admission and the costs of admission to hospital-at-home in the six  
32 months after discharge.  
33  
34

### 35 36 37 *Patient involvement*

38  
39 Patients were not involved in this retrospective analysis of administrative data.  
40  
41

## 42 43 **Results**

### 44 45 46 *Characteristics of the population cohorts*

47  
48 Between August 2014 and December 2015 (17 months) 1771 patients were admitted to hospital-at-  
49 home in site one, between January 2015 and December 2016 (24 months) 1547 patient were  
50 admitted to hospital-at-home in site two, and between August 2014 and December 2015 (17  
51 months) 443 patients were admitted to hospital-at-home in site three (Figure 2). In the same period,  
52 there were 14220 patients admitted to 3 hospitals in site one, 5399 patients admitted to 1 hospital  
53 in site two, and 2295 patients admitted to 1 hospital in site three.  
54  
55  
56  
57

1  
2  
3 There were few differences between the hospital-at-home cohorts in site one, site two, and site  
4 three, the main difference being that a larger proportion of the population in site two lived in a more  
5 affluent area (i.e. scored five or higher on the SIMD). Patients admitted to hospital-at-home were on  
6 average three to four years older than those admitted to hospital, were more likely to be female  
7 (ranging from 5 percentage points in site three to 9 percentage points in site two), and a higher  
8 proportion had more than four long-term conditions (approximately 7 percentage points) compared  
9 with patients admitted to hospital (Table 1). The largest difference between those admitted to  
10 hospital-at-home and to hospital in site one and site two was in the proportion of patients with  
11 dementia (10 percentage points higher in the hospital-at-home cohorts), while in site three it was  
12 the proportion of patients with renal failure (also 10 percentage points higher in the hospital-at-  
13 home cohort).

14  
15  
16 We compared the two cohorts in each site, from index admission to six months post discharge from  
17 hospital-at-home or hospital (Table 2). In all sites there was on average a higher percentage of  
18 deaths while receiving healthcare in hospital compared with those receiving healthcare in hospital-  
19 at-home (6% vs., 1% site one; 6% vs., 3% site two; 4% vs., 1% site three), and a higher percentage of  
20 deaths (21% vs., 28% site one; 22% vs., 32% site two; 17% vs., 27% site three) during the whole  
21 follow-up period (i.e. during admission and six months after discharge) in the group that had  
22 received hospital-at-home. Patients in the hospital-at-home cohort lived on average eight (site one),  
23 ten (site two), and twelve (site three) fewer days during the whole follow-up, and their index  
24 admission was on average fewer days in site one (mean unadjusted difference -2.64, 95%CI -2.97 to -  
25 2.31) and site three (mean unadjusted difference -2.02, 95%CI -2.66 to -1.37) and longer in site two  
26 (mean unadjusted difference 1.25, 95% CI 0.86 to 1.64).

27  
28  
29 The cost during a hospital-at-home admission was on average lower than hospital admission in site  
30 one (mean difference -£2318; 95%CI: £-2420 to £-2217) and site three (mean difference -£1096;  
31 95%CI: £-1398 to £-793), and slightly lower (mean difference £-153; 95%CI: £-277; to £-29) in site  
32 two. In the hospital-at-home cohort, these costs included the intervention costs of delivering the  
33 service at home, which were £628 per admission and £113 per day in site one, £2928 per admission  
34 and £398 per day in site two, and £864.54 per admission and £117.57 per day in site three. In each  
35 Health Board, staff were the major driver of intervention (i.e. hospital-at-home) cost (site one 95%,  
36 site two 87%, site three 94%). Detailed information on the interventions costs in site one, site two,  
37 and site three are presented in Appendix 1.

38  
39  
40 In site one, in the two years prior to the index admission, the hospital-at-home cohort had on  
41 average 40% (mean difference £3219; 95%CI: £2513 to £3925) more healthcare costs, driven  
42 primarily by higher costs of non-elective hospitalisation. We observed a similar pattern in site two  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52

1  
2  
3 and site three where the mean costs in the hospital-at-home-cohort were on average 56% higher  
4 (mean difference £5064; 95%CI: £3984 to £6143) and 57% (mean difference £4115; 95%CI: £2467 to  
5 £5764) respectively and again were due to non-elective hospitalisation. In the six months following  
6 discharge, and excluding the costs of the index admission, costs were on average 43% higher (mean  
7 difference £1839; 95%CI: £1423 to £2255) in site one for those who had been admitted to hospital-  
8 at-home, in site two they were 16% higher (mean difference £875, 95%CI: £156 to £1595), and in  
9 site three they were 92% higher (mean difference £3068, 95%CI: £2178 to £3958). The larger  
10 increase in costs in all sites was due to higher non-elective hospitalisation costs in the group who  
11 had received hospital-at-home care (mean difference £1517, 95%CI £1134 to 1899 site one; mean  
12 difference £529, 95%CI £-77 to 1135 site two; mean difference £2618, 95%CI £1779 to 3458 site  
13 three) during the six months follow-up.

14  
15  
16  
17  
18  
19  
20  
21 When the cost of the index admission was included in the analysis, the cost during follow-up (i.e.  
22 including the index admission and 6-months healthcare resource use after index discharge) was 6%  
23 lower (mean difference -£480, 95%CI: £-996 to £36) in the hospital-at-home cohort, compared with  
24 the control cohort in site one; while these costs were 8% higher in site two (mean difference £722,  
25 95%CI: £32 to £1413) and 35% higher in site three (mean difference £1973, 95%CI: £1019 to £2927).

26  
27  
28  
29 Compared with the control cohort, the mean costs per lived day were 13% (mean difference £-12;  
30 95%CI: -17 to -6) lower in the hospital-at-home cohort in site one, while these costs were 34% higher  
31 (mean difference £37; 95%CI: 18 to 56) and 66% higher (mean difference £36; 95%CI: 18 to 53) in  
32 site two and site three respectively.  
33  
34  
35  
36  
37

38 Figure 2 Flowchart of study population  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

Table 1 Patient characteristics at index admission

Variable	Site one		Site two		Site three	
	Control (n=13139)	HAH (n=1737)	Control (n=3994)	HAH (n=1463)	Control (n=1844)	HAH (n=433)
Mean age on admission (se)	77.8 (0.07)	81.2 (0.17)**	78.5 (0.13)	82.2 (0.21)**	77.3 (0.18)	81.4 (0.34)**
Female	7,468 (57%)	1,096 (63%)**	2,102 (53%)	909 (62%)**	1037 (56%)	266 (61%)*
Higher than 4 on the SIMD	5,005 (38%)	609 (35%)**	1,960 (49%)	775 (53%)*	837 (45%)	192 (44%)
More than 4 chronic conditions	4,974 (38%)	777 (45%)**	1,664 (42%)	725 (50%)**	659 (36%)	185 (43%)**
Arthritis	3,431 (26%)	497 (29%)*	1,455 (37%)	572 (39%)	606 (33%)	155 (36%)
Asthma	1,370 (10%)	183 (11%)	497 (13%)	207 (14%)	177 (10%)	49 (11%)
Atrial fibrillation	3,659 (28%)	488 (28%)	1,555 (29%)	468 (32%)*	498 (27%)	126 (29%)
Cancer	3,749 (29%)	485 (28%)	1,261 (32%)	371 (25%)**	580 (31%)	124 (29%)
CVD	2,922 (22%)	467 (27%)**	763 (19%)	392 (27%)**	373 (20%)	114 (26%)**
Liver disease	499 (4%)	50 (3%)	183 (5%)	52 (4%)	72 (4%)	20 (5%)
COPD	3,641 (28%)	505 (29%)	1,083 (27%)	428 (29%)	510 (28%)	132 (31%)
Dementia	1,999 (15%)	439 (25%)**	665 (17%)	390 (27%)**	223 (12%)	74 (17%)**
Diabetes	2,985 (23%)	403 (23%)	948 (24%)	350 (24%)	410 (22%)	115 (27%)*
Epilepsy	459 (4%)	75 (4%)	146 (4%)	78 (5%)**	53 (3%)	10 (2%)
CHD	5,034 (38%)	733 (42%)**	1,425 (36%)	575 (39%)*	624 (34%)	141 (33%)
Heart failure	2,197 (17%)	404 (23%)**	744 (19%)	32 (23%)**	328 (18%)	109 (25%)**
MS	73 (1%)	6 (0%)	21 (1%)	17 (1%)*	14 (1%)	2 (1%)
Parkinson's	293 (2%)	66 (4%)**	82 (2%)	53 (4%)**	53 (3%)	20 (5%)
Renal failure	2,501 (19%)	394 (23%)**	780 (20%)	339 (23%)**	284 (15%)	110 (25%)**
Congenital problems	277 (2%)	38 (2%)	159 (4%)	51 (4%)	51 (3%)	9 (2%)
Diseases of blood	3,784 (29%)	553 (32%)**	1,143 (29%)	426 (29%)	485 (26%)	125 (29%)
Endocrine metabolic disease	4,505 (34%)	624 (36%)	1,737 (44%)	652 (45%)	642 (35%)	151 (35%)
Disease of digestive system	9,341 (71%)	1,249 (72%)	2,710 (68%)	1,006 (69%)	1145 (62%)	286 (66%)

\* p<0.05 \*\* p<0.01 in chi-square test for categorical and Mann-Whitney for continuous variables to test differences between HAH and control; HAH: hospital-at-home; SIMD ranges from 1 (most deprived) to 10 (most affluent); Note: a patient could be registered with more than one ICD-10 codes;

Table 2. Mortality, resource utilisation and costs

Variable	Site one			Site two			Site three		
	Control (n=13139)	HAH (n=1737)	Mean difference or risk ratio (95%CI)	Control (n=3994)	HAH (n=1463)	Mean difference or risk ratio (95%CI)	Control (n=1844)	HAH (n=433)	Mean difference or risk ratio (95%CI)
Died during index admission	844 (6%)	20 (1%)	0.18 (0.12;0.28) <sup>###</sup>	256 (6%)	47 (3%)	0.50 (0.37;0.68) <sup>###</sup>	78 (4%)	2 (1%)	0.11 (0.03;0.44) <sup>###</sup>
Died during follow-up including index admission	2,787 (21%)	483 (28%)	1.31 (1.21;1.42) <sup>###</sup>	867 (22%)	471 (32%)	1.48 (1.35;1.63) <sup>###</sup>	319 (17%)	116 (27%)	1.55 (1.29;1.86) <sup>###</sup>
Means days alive during follow-up (se)	159 (0.50)	151 (1.45)	-8.32 (-11.32;-5.32)	156 (0.91)	146 (1.72)	-10.10 (-14;-7)	163 (1.22)	151 (2.88)	-12 (-18;-6)
Mean length of index admission in days (se)	8.18 (0.12)	5.54 (0.13)	-2.64 (-2.97;-2.31)	6.10 (0.14)	7.35 (0.14)	1.25 (0.86;1.64)	6.36 (0.26)	4.34 (0.20)	-2.02 (-2.66;-1.37)
Mean 2 year historical costs (se)									
A&E	173 (2)	253 (7)	80 (65;94)	136 (4)	180 (6)	44 (28;60)	143 (5)	202 (12)	59 (31;87)
Elective hospital care	985 (37)	956 (134)	-28 (-352;295)	1,027 (64)	705 (86)	-321 (-519;-123)	981 (87)	1036 (372)	55 (-723;833)
Non-elective hospital care	4,037 (79)	6,945 (266)	2908 (2452;3364)	5,101 (185)	9,593 (394)	4492 (3804;5179)	3978 (211)	7832 (614)	3854 (2591;5118)
Hospital day case	707 (25)	439 (32)	-269 (-340;-197)	625 (66)	290 (44)	-336 (-479;-193)	544 (49)	358 (55)	-186 (-334;-38)
Geriatric long stay	360 (27)	504 (82)	143 (-66;354)	117 (29)	252 (72)	135 (-13;283)	105 (31)	229 (59)	125 (14;235)
Mental ward	247 (32)	367 (117)	119 (-177;411)	347 (79)	1,053 (205)	706 (265;1147)	220 (75)	252 (139)	32 (-329;393)
Outpatient	173 (2)	173 (5)	0 (-11;11)	222 (4)	206 (6)	-15 (-30;0)	212 (6)	201 (12)	-11 (-38;15)
Medication (GP prescriptions)	1,468 (15)	1,733 (43)	256 (187;341)	1,524 (28)	1,883 (52)	360 (253;466)	1034 (39)	1221 (78)	188 (30;346)
Total	8,149 (109)	11,369 (359)	3219 (2513;3925)	9,098 (239)	14,162 (477)	5064 (3984;6143)	7217 (267)	11333 (772)	4115 (2467;5764)
Mean costs during index admission (se)	3,195 (41)	877 <sup>#</sup> (32)	-2318 (-2420;-2217)	3,426 (71)	3,273 <sup>#</sup> (32)	-153 (-277;-29)	2383 (90)	1287 (132)	-1096 (-1398;-793)
Mean costs 6 months after index discharge (se)									
A&E	72 (1)	88 (3)	17 (11;22)	55 (2)	53 (3)	-2 (-9;4)	59 (2)	71 (5)	12 (-1;25)
Elective hospital care	305 (20)	157 (40)	-148 (-236;-60)	272 (28)	204 (50)	-68 (-190;53)	169 (33)	313 (117)	144 (-92;380)
Non-elective hospital care	2,444 (51)	3,961 (171)	1517 (1134;1899)	3,942 (130)	4,471 (251)	529 (-77;1135)	2029 (123)	4648 (421)	2618 (1779;3458)
Hospital day case	237 (11)	73 (11)	-164 (-191;-138)	234 (24)	96 (21)	-139 (-198;-79)	168 (23)	63 (15)	-105 (-162;-48)
Geriatric long stay	643 (45)	1,014 (131)	371 (79;663)	218 (34)	150 (46)	-68 (-178;41)	320 (56)	700 (186)	381 (-73;834)
Mental ward	165 (22)	206 (51)	41 (-58;140)	299 (56)	259 (77)	-40 (-224;143)	211 (65)	120 (62)	-91 (-245;64)
Outpatient	54 (1)	45 (2)	-9 (-13;-5)	61 (2)	54 (3)	-8 (-14;-2)	65 (3)	67 (6)	2 (-12;16)
Medication (GP prescriptions)	392 (5)	415 (13)	23 (-5;52)	402 (9)	482 (16)	80 (45;115)	314 (12)	338 (27)	24 (-28;76)
Hospital-at-home	4 (1)	196 (11)	193 (170;216)	50 (7)	642 (45)	592 (506;679)	7 (1)	90 (12)	83 (59;108)
Total	4,316 (78)	6,155 (240)	1839 (1423;2255)	5,535 (154)	6,410 (286)	875 (156;1595)	3342 (163)	6410 (510)	3068 (2178;3958)
Mean costs in follow-up (se) including index admission	7,513 (92)	7,031 (243)	-480 (-996;36)	8,961 (180)	9,683 (290)	722 (32;1413)	5724 (199)	7697 (521)	1973 (1019;2927)
Mean costs per lived day in follow-up (se)	83 (1)	72 (3)	-12 (-17;-6)	109 (3)	146 (8)	37 (18;56)	55 (2)	91 (8)	36 (18;53)

# it includes the interventions costs (i.e. £628 in site one, £2,928 in site two, and £865.54 in site three) and other costs occurred during the episode; ## Unadjusted Risk Ratio;

### *Selection of propensity score matching technique*

In the propensity score matched analysis, there were 1696, 925, and 427 patients in the hospital-at-home cohort and 11571, 3849, and 1683 patients in the hospital cohort in site one, site two, and site three respectively (Figure 2). Local linear regression matching was the best PSM technique to match the cohorts in site one and site three for costs and mortality, as it resulted in a lower mean (i.e. 1.5 and 1.8 respectively) and median (i.e. 1.2 and 1.6 respectively) percentage standardised bias, as well as the lowest Rubin's B (i.e. 9.4 and 9.6 respectively). Based on the same criteria, Kernell matching was selected to match the cohorts in site two. Rubin's R was within the suggested range (i.e. from 0.5 to 2) in the selected techniques. These results are presented in Appendix 2.

### *Main propensity score matched analysis*

The results of the main analysis are presented in Panel A in Table 3. After propensity score matching and regression analysis, the healthcare cost during index admission in hospital-at-home and over six months after index discharge was on average 18% lower (ratio of means: 0.82; 95%CI: 0.76 to 0.89) than admission to hospital in site one. Excluding the cost of the index admission (hospital-at-home or hospital) the costs during the six months following discharge for those who had been admitted to hospital-at-home were on average 27% higher (ratio of means: 1.27; 95%CI: 1.14 to 1.41) compared with patients who had been admitted to hospital. In site two, the difference in costs between the cohorts was close to zero (ratio of means: 1.00; 95%CI 0.92 to 1.09) during the index admission and six month follow-up period; and 9% (ratio of means: 1.09; 95%CI: 0.95 to 1.24) more costly in the six months after index discharge (i.e. excluding the index admission). In site three, patients admitted to hospital-at-home had on average 15% higher cost during the entire follow-up period (ratio of means: 1.15; 95%CI 0.99 to 1.33) and 70% higher cost during the six months after discharge (ratio of means: 1.70; 95%CI 1.40 to 1.07) compared with patients admitted to hospital.

There may be an increased risk of mortality in all three hospital-at-home cohorts (site one: relative risk 1.09; 95%CI 1.00 to 1.19) (site two: relative risk 1.29; 95%CI: 1.15 to 1.44) (site three: relative risk 1.27; 95%CI: 1.06 to 1.54) compared with the hospital cohort after PSM and regression to adjust for confounding. The Kaplan-Meier survival curves presented in Figure 3 show higher survival rates in the inpatient control cohorts in all three sites, and after weighting with the propensity score the control cohort in site two still had a higher survival rate than the hospital-at-home cohort. The difference in survival in site three between the results reported in Table 3 and the survival curve after weighting is explained by the fact that Kaplan-Meier curves are only weighted with the propensity score without performing an additional regression analysis.

Table 3. Results of the propensity score matched regression analyses

<b>Panel A: main analysis</b>			
<i>Outcome variable</i>	<i>Site one (n=13267)</i>	<i>Site two (n=4769)</i>	<i>Site three (n=2110)</i>
Total costs during follow-up period <sup>#</sup>	0.82 (0.03) [0.76;0.89] <0.001	1.00 (0.05) [0.92;1.09] 0.982	1.15 (0.09) [0.99;1.33] 0.073
Total costs in 6 months after discharge	1.27 (0.07) [1.14;1.41] <0.001	1.09 (0.07) [0.95;1.24] 0.219	1.70 (0.17) [1.40;2.07] <0.001
Mortality rate during follow-up	1.09 (0.05) [1.00;1.19] 0.059	1.29 (0.07) [1.15;1.44] <0.0010	1.27 (0.12) [1.06;1.54] 0.011
<b>Panel B: subgroup analysis including only patients with dementia</b>			
<i>Outcome variable</i>	<i>Site one (n=2321)</i>	<i>Site two (n=1053)</i>	<i>Site three (n=280)</i>
Total costs during follow-up period <sup>#</sup>	0.76 (0.05) [0.66;0.87] <0.001	0.76 (0.06) [0.66;0.88] <0.001	0.87 (0.15) [0.63;1.21] 0.409
Total costs in 6 months after discharge	1.18 (0.11) [0.99;1.41] 0.071	0.75 (0.09) [0.59;0.96] 0.021	1.58 (0.41) [0.95;2.63] 0.078
Mortality rate during follow-up	1.05 (0.09) [0.89;1.24] 0.594	1.41 (0.12) [1.19;1.67] <0.001	1.65 (0.32) [1.12;2.41] 0.011
<b>Panel C: subgroup analysis including only survivors</b>			
<i>Outcome variable</i>	<i>Site one (n=10132)</i>	<i>Site two (n=3584)</i>	<i>Site three (n=1691)</i>
Total costs during follow-up period <sup>#</sup>	0.85 (0.04) [0.77;0.94] 0.002	1.11 (0.03) [1.00;1.25] 0.058	1.20 (0.11) [1.00;1.43] 0.046
Total costs in 6 months after discharge	1.23 (0.08) [1.08;1.40] 0.002	1.17 (0.10) [0.99;1.38] 0.070	1.71 (0.20) [1.36;2.15] <0.001
<b>Panel D: sensitivity analysis</b>			
<i>Outcome variable</i>	<i>Site one (n=13267)</i>	<i>Site two (n=4769)</i>	<i>Site three (n=2110)</i>
Total costs during follow-up period <sup>#</sup> (assuming 50% lower intervention costs)	0.77 (0.03) [0.71;0.84] <0.001	0.81 (0.04) [0.74;0.9] 0.001	1.07 (0.09) [0.91;1.25] 0.399
Total costs during follow-up period <sup>#</sup> (assuming 50% higher intervention costs)	0.87 (0.03) [0.81;0.94] 0.001	1.18 (0.05) [1.09;1.28] <0.001	1.23 (0.09) [1.07;1.42] 0.004

# It includes the index admission period and 6 months post-discharge; Note: The results are presents as coefficient (se) [95%CI] p value; The results are after matching and adjusting for age, gender, socio-economic status, primary and secondary ICD-10 codes of index admission, type of long-term condition, mortality (for the analysis of costs), 2-year costs prior to the index admission (by cost category as listed in Box 1).

Figure 3. Survival curves before and after propensity score matching

### Results of the subgroup analysis

Patients with dementia (Panel B in Table 3) admitted to hospital-at-home services in site one and site two had about 25% lower costs (site one: ratio of means 0.75; 95%CI 0.65 to 0.87; site two: ratio of means 0.76 95%CI: 0.66 to 0.88) during the index admission and six months post-discharge. After excluding the index admission period, the same difference in mean costs remained in site two. We found that the population who were admitted to hospital-at-home, and had a diagnosis of dementia, may have an increased risk of death in two sites (site two: relative risk 1.41, 95%CI 1.19 to 1.67; site three: relative risk 1.65, 95%CI 1.12 to 2.41) compared with those who had a diagnosis of dementia and who were admitted to hospital.

When we excluded people who died during follow-up (i.e. during index admission and 6 months after discharge), patients admitted to hospital-at-home in site one had lower costs (ratio of means 0.85, 95%CI: 0.77 to 0.94), while there was 11% increase in costs in site two (ratio of means 1.11, 95%CI: 1.00 to 1.25) and 20% increase in site three (ratio of means 1.20, 95%CI: 1.00 to 1.43); the mean costs were higher in the hospital-at-home cohort when the costs during the index admission were excluded (site one: ratio of means 1.23, 95%CI: 1.08 to 1.40; site two: ratio of means 1.17, 95% CI 0.99 to 1.38; site three: ratio of means 1.71, 95% CI 1.36 to 2.15) compared with patients admitted to hospital (Panel C in Table 3).



### *Results of the sensitivity analyses*

The results from the sensitivity analysis (Panel D in Table 3) showed that patients in the hospital-at-home cohort in site one had 13% lower costs (ratio of means 0.87; 95%CI: 0.81 to 0.94) during the follow-up period (i.e. during index admission and 6 months after index discharge) when the hospital-at-home service costs were assumed to be 50% higher than in the main analysis. In site two, the results from the sensitivity analysis showed that the uncertainty in hospital-at-home service costs lead to increased costs or cost savings by about 18% during the whole follow-up period. In site three, the sensitivity analysis showed a 23% cost increase (ratio of means 1.23; 95%CI: 1.07 to 1.42), if the intervention costs of hospital-at-home were 50% higher.

## Discussion

### *Main findings*

Patients who received healthcare from the hospital-at-home services were older, were more socioeconomically disadvantaged, had higher morbidity (measured by the number of long term conditions), higher rates of previous hospitalisation, and there was a greater proportion of women compared with the group admitted to hospital. The two groups also differed in terms of their clinical diagnosis, with the most marked difference across the three services being a greater percentage (five to ten percent difference) of people with dementia. The higher healthcare costs over the two years prior to index admission in those admitted to hospital-at-home were mainly driven by the costs of non-elective hospital care. The cost of providing hospital-at-home varied between the three sites from £628 to £2928 per admission, and costs were driven primarily by staff costs. Our findings indicate that hospital-at-home might be associated with an increase in healthcare costs in the six months after index discharge. However, this increase in costs might be offset by likely cost-savings during the index admission. The higher healthcare cost at six months after index discharge, was driven primarily by acute non-elective admissions. Interpreting this is not straightforward; it might indicate a lack of resources during the index admission to hospital-at-home, or an increased risk of hospital admission in the population who receive their healthcare through hospital-at-home. The suggestion of an increased risk of mortality at six months after the index admission might be genuine, or could indicate that propensity score matching did not control for all differences between the groups and thus, the estimates are subject to residual confounding.<sup>13 14</sup>

### *Comparison with previous studies*

A meta-analysis of six small randomised controlled trials concluded that admission avoidance hospital-at-home probably makes little or no difference to the risk of death or transfer to hospital at

1  
2  
3 six months' follow-up, and might increase the likelihood of living at home (albeit with low-certainty  
4 evidence); and highlighted the lack of evidence on cost.<sup>2</sup> Studies that have used 'real life data' offer  
5 the potential to address criticisms of limited external validity from randomised trials; and propensity  
6 score matching is one technique that has been used to balance co-variables when analysing routinely  
7 collected health data to assess these type of service delivery interventions. Findings have been  
8 consistent, and previous studies have reported higher rates of mortality and unplanned admission  
9 for those who received an intermediate care intervention, compared with matched controls.<sup>6 14 15</sup>  
10  
11 However, it is possible that these findings are subject to residual confounding.  
12  
13

### 14 15 16 *Potential mechanisms and interpretation*

17  
18 Healthcare services that cross the interface of primary and secondary care can bridge and  
19 strengthen the integration of acute and community services, and social care. However, by definition  
20 this can lead to a complex arrangement of services that reflect availability of local resources,<sup>16</sup> and a  
21 willingness to innovate. The hospital-at-home services evaluated in this analysis were established to  
22 reduce the demand for acute hospital beds by providing an alternative to admission to hospital, and  
23 to lower the risk of functional decline from the limited mobility that older people might experience  
24 when in hospital. However, it is possible that the services have several functions, for example by  
25 providing both rapid response and reablement, and this is reflected in the diverse population  
26 included in this analysis.  
27  
28  
29  
30  
31

### 32 33 *Implications for clinicians and policy makers*

34  
35 The variation in intervention costs of the three hospital-at-home services is primarily driven by staff  
36 costs, and the findings of the sensitivity analysis confirms that staff costs are likely to determine  
37 whether a hospital-at-home service leads to higher costs or cost savings. The skill-mix of healthcare  
38 professionals who provide hospital-at-home should be guided by national standards, the type of  
39 patients the service targets, and the function of the service in terms of whether or not the service  
40 supplements existing community based healthcare, substitutes for hospital level care, augments  
41 palliative care services or a combination of these. The integration of these types of service with  
42 existing primary and secondary care services, for example the provision of out-of-hours care by  
43 primary care services, might also determine the costs of these services. Managerial capacity of these  
44 services is expected to be of crucial importance in setting-up and managing the team of  
45 professionals able to provide high quality care.  
46  
47  
48  
49  
50  
51

52  
53 The absence of evidence based guidelines about who and under which conditions a patient may be  
54 admitted to admission avoidance hospital-at-home might explain the variation in the set-up of  
55 services, and the relatively small size of the services. This is confirmed by the National Audit of  
56  
57  
58  
59  
60

1  
2  
3 Intermediate Care ,<sup>17</sup> that was established in response to concerns about governance structures in  
4 intermediate care services, and reported a complex pattern of service provision.  
5

6 Data on the role and capability of informal care givers is largely absent. In many cases, people  
7 admitted to hospital-at-home services receive care from their partners who if old might have health  
8 issues themselves. In the context of our findings, that patients admitted to hospital-at-home services  
9 are older and more fragile than patients admitted to hospital, there might be a risk that carers are  
10 overburdened by being involved in the provision of healthcare.  
11  
12  
13

### 14 *Strengths and limitations*

15  
16 The strengths of this study include the dataset from three of the largest Health Boards in Scotland,  
17 the quasi-experimental study design that has allowed inferences from real world evidence, and the  
18 sensitivity analyses that helped to address uncertainty in the results. The major limitation of this  
19 type of non-randomised comparison is residual confounding. While matching individuals and  
20 performing regression analysis can reduce this risk, it is possible that the two populations differed in  
21 frailty because we did not match and adjust for differences in the use of community and social  
22 services prior to index admission. If unobserved confounders were part of the clinical-decision  
23 making by GPs and geriatricians to admit patients to hospital-at-home or hospital, our findings might  
24 be biased due to confounding by clinical indication. This type of confounding is often not measured  
25 directly because standardised criteria are not available to guide clinical decision-making.<sup>18 19</sup>  
26 Therefore, the magnitude of this bias in our results depends on the clinical-decision making process  
27 to admit patients to hospital-at-home in the three sites. If clinicians did not consider hospital-at-  
28 home as a substitute service to hospitalisation then confounding by indication would increase the  
29 residual confounding in our analysis. GPs and geriatricians who refer patients to hospital-at-home  
30 are likely to have a clinical bias in preferring to keep older, frailer and terminally ill patients in their  
31 own home. Using hospital-at-home admission criteria to define the control cohort accepts that such  
32 open criteria will include general medical patients who are likely to have fewer comorbidities, be  
33 younger and with a longer life expectancy. However, as the results of the survivors' subgroup  
34 analysis were very similar with the results of the main cost analysis we expect that the magnitude of  
35 the residual confounding to be small. Furthermore, the use of routine data has been used to reliably  
36 identify older people with frailty,<sup>20</sup> and approaches using clinical codes to define this population are  
37 being tested.<sup>21</sup>  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51

### 52 *Future research*

53  
54 Guidance on the use of real life data to evaluate service delivery interventions is largely absent, and  
55 could provide healthcare decision-makers with a relatively inexpensive way of evaluating local  
56 service innovations and how to avoid pitfalls in analysis and interpretations. Similar to all  
57  
58  
59  
60

1  
2  
3 observational studies, the findings of this study may be used to identify important questions to be  
4 tested in randomised trials.<sup>18</sup> A multi-centre randomised trial that measures outcomes that are key  
5 to decision-makers (including informal care giving), and is accompanied by a process evaluation to  
6 help explain the findings, is necessary to provide clinicians and policy makers with further evidence  
7 about the effectiveness and cost-effectiveness of admission avoidance hospital-at-home services  
8 across UK. The authors are involved in such a trial the results of which are expected to be available in  
9 2019.<sup>22</sup>

## 15 Conclusions

18 We found differences in the populations admitted to hospital-at-home and hospital. The likely  
19 higher cost in all three hospital-at-home cohorts compared with the hospital cohorts during the six  
20 months following discharge, highlight the importance of characterising populations eligible to  
21 receive these types of healthcare services and of assessing subsequent use of health, social, and  
22 informal care following admission to hospital-at-home or hospital.

## 27 Competing interests

30 All authors have completed the ICMJE uniform disclosure form. GE is employed at the Monklands  
31 hospital and leading the hospital-at-home service in site one. All other authors declare no support  
32 from any organisation for the submitted work; no financial relationships with any organisations that  
33 might have an interest in the submitted work in the previous three years; no other relationships or  
34 activities that could appear to have influenced the submitted work.

## 39 Details of contributors

42 AT, GE, and SS were responsible for study concept, GE facilitated the acquisition of data; AF and SS  
43 led the writing of the protocol, study design and drafting of the manuscript; AT performed the  
44 statistical analysis. All authors interpreted the data, critically revised the manuscript for important  
45 intellectual content and approved the final version for submission. AT and SS are guarantors.

## 49 Acknowledgement

52 We would like to thank Charmaine Walker, Jenny Boyd, Alistair Smith and Josh Matthews from ISD  
53 Scotland for providing us with the data as well as Christine McGregor (economist in the Scottish  
54 Government) for her insightful views and expertise. We are also indebted to Dr Mike Gardner and  
55 Prof Alastair Gray (both University of Oxford), Prof Stavros Petrou (University of Warwick), and Dr

Matthew Sperrin (University of Manchester) for commenting on previous drafts of the manuscript. Our thanks also to Prof Gillian Parker (University of York), Dr Angela Coulter (University of Oxford) and Prof Stuart Parker (University of Newcastle) for their useful reflection on the study findings. Finally, we would like to thank all healthcare staff in all three sites who made this study happen.

## Ethical approval

We obtained signed release forms from each Health Board's Caldicott guardian.

## Funding

NIHR, UK. (12/5003//01; "How to Implement Cost-Effective Comprehensive Geriatric Assessment")

## Data sharing agreement

No additional data are available.

## References

1. World Health Organization. Noncommunicable diseases progress monitor 2015. Geneva: World Health Organization, 2015.
2. Shepperd S, Iliffe S, Doll HA, et al. Admission avoidance hospital at home. *Cochrane Database Syst Rev* 2016;9:CD007491. doi: 10.1002/14651858.CD007491.pub2
3. Sherman RE, Anderson SA, Dal Pan GJ, et al. Real-World Evidence - What Is It and What Can It Tell Us? *N Engl J Med* 2016;375(23):2293-97. doi: 10.1056/NEJMs1609216
4. Johns B, Baltussen R, Hutubessy R. Programme costs in the economic evaluation of health interventions. *Cost effectiveness and resource allocation : C/E* 2003;1(1):1.
5. Stuart EA. Matching methods for causal inference: A review and a look forward. *Statistical science : a review journal of the Institute of Mathematical Statistics* 2010;25(1):1-21. doi: 10.1214/09-STS313
6. Garrido MM, Kelley AS, Paris J, et al. Methods for constructing and assessing propensity scores. *Health Serv Res* 2014;49(5):1701-20. doi: 10.1111/1475-6773.12182
7. Baser O. Too much ado about propensity score models? Comparing methods of propensity score matching. *Value Health* 2006;9(6):377-85. doi: 10.1111/j.1524-4733.2006.00130.x
8. Craig P, Cooper C, Gunnell D, et al. Using natural experiments to evaluate population health interventions: new Medical Research Council guidance. *J Epidemiol Community Health* 2012;66(12):1182-6. doi: 10.1136/jech-2011-200375
9. Rubin DB. Using propensity scores to help design observational studies: application to the tobacco litigation. *Health Services & Outcomes Research Methodology* 2001;2:169-88.
10. Funk MJ, Westreich D, Wiesen C, et al. Doubly robust estimation of causal effects. *Am J Epidemiol* 2011;173(7):761-7. doi: 10.1093/aje/kwq439
11. Leist AK. Social Inequalities in Dementia Care, Cure, and Research. *J Am Geriatr Soc* 2017;65(5):1100-01. doi: 10.1111/jgs.14893
12. World Health Organization. Draft global action plan on the public health response to dementia, 2016.

13. Iliffe S. Hospital at home: from red to amber?. Data that will reassure advocates-but without satisfying the sceptics. *Bmj* 1998;316(7147):1761-2.
14. Steventon A, Bardsley M, Billings J, et al. The role of matched controls in building an evidence base for hospital-avoidance schemes: a retrospective evaluation. *Health Serv Res* 2012;47(4):1679-98. doi: 10.1111/j.1475-6773.2011.01367.x
15. Lewis G, Vaithianathan R, Wright L, et al. Integrating care for high-risk patients in England using the virtual ward model: lessons in the process of care integration from three case sites. *Int J Integr Care* 2013;13:e046.
16. Young J, Gladman JR, Forsyth DR, et al. The second national audit of intermediate care. *Age Ageing* 2015;44(2):182-4. doi: 10.1093/ageing/afu174
17. NHS Benchmarking Network. Summary report- England. National audit of intermediate care: NHS Benchmarking Network, 2017.
18. Freemantle N, Marston L, Walters K, et al. Making inferences on treatment effects from real world data: propensity scores, confounding by indication, and other perils for the unwary in observational research. *Bmj* 2013;347:f6409. doi: 10.1136/bmj.f6409
19. Wong AY, Root A, Douglas IJ, et al. Cardiovascular outcomes associated with use of clarithromycin: population based study. *Bmj* 2016;352:h6926. doi: 10.1136/bmj.h6926
20. Clegg A, Bates C, Young J, et al. Development and validation of an electronic frailty index using routine primary care electronic health record data. *Age Ageing* 2017 doi: 10.1093/ageing/afx001
21. Ham C, York N, Sutch S, et al. Hospital bed utilisation in the NHS, Kaiser Permanente, and the US Medicare programme: analysis of routine data. *Bmj* 2003;327(7426):1257. doi: 10.1136/bmj.327.7426.1257
22. Shepperd S, Craddock-Bamford A, Butler C, et al. A multi-centre randomised trial to compare the effectiveness of geriatrician-led admission avoidance hospital at home versus inpatient admission. *Trials* 2017;18(1):491. doi: 10.1186/s13063-017-2214-y

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

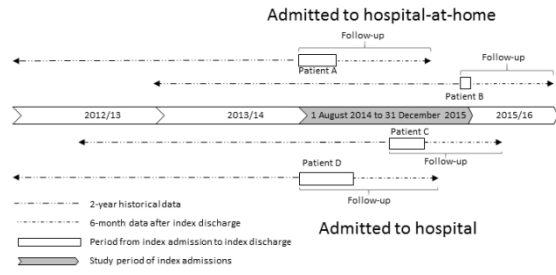


Figure 1. Illustration of obtained data from site one  
338x190mm (96 x 96 DPI)

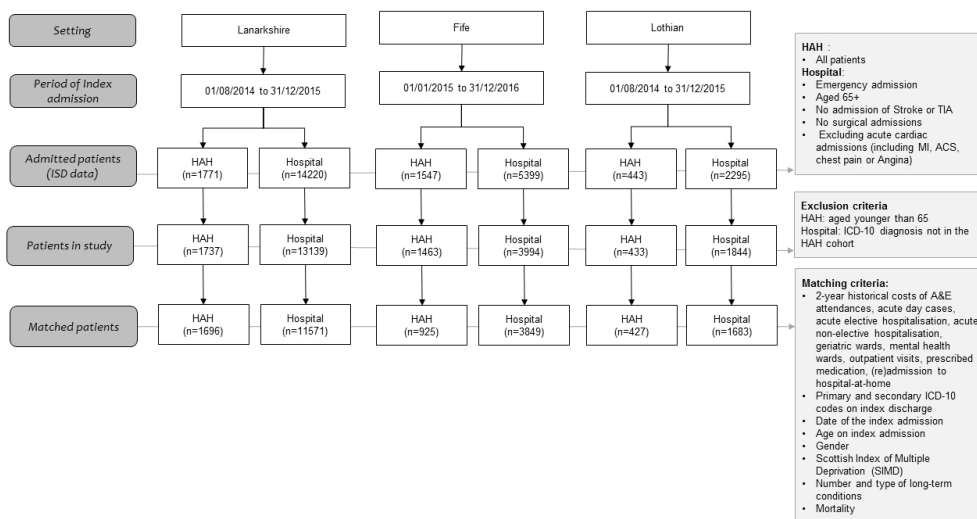
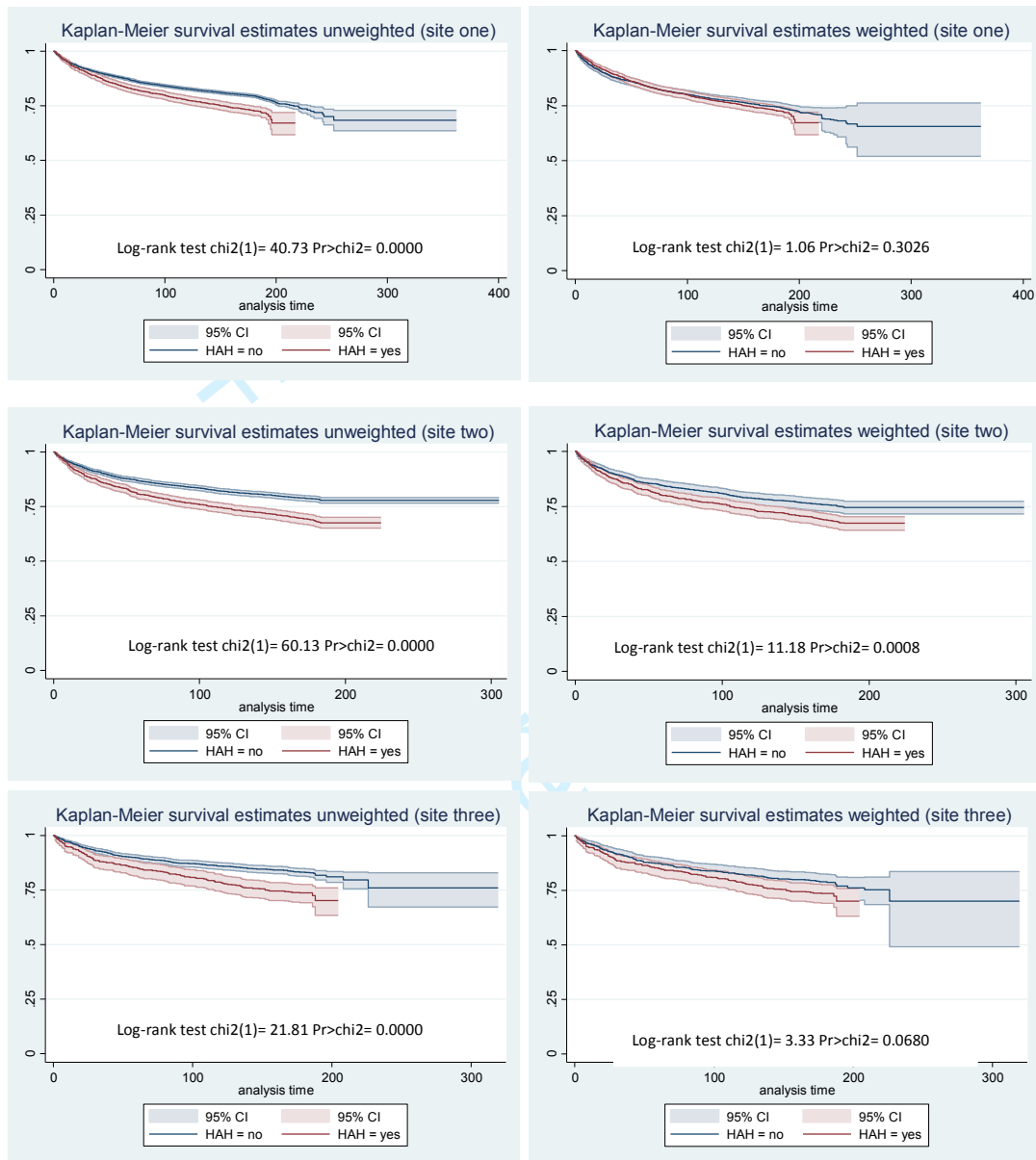


Figure 2 Flowchart of study population

338x190mm (96 x 96 DPI)

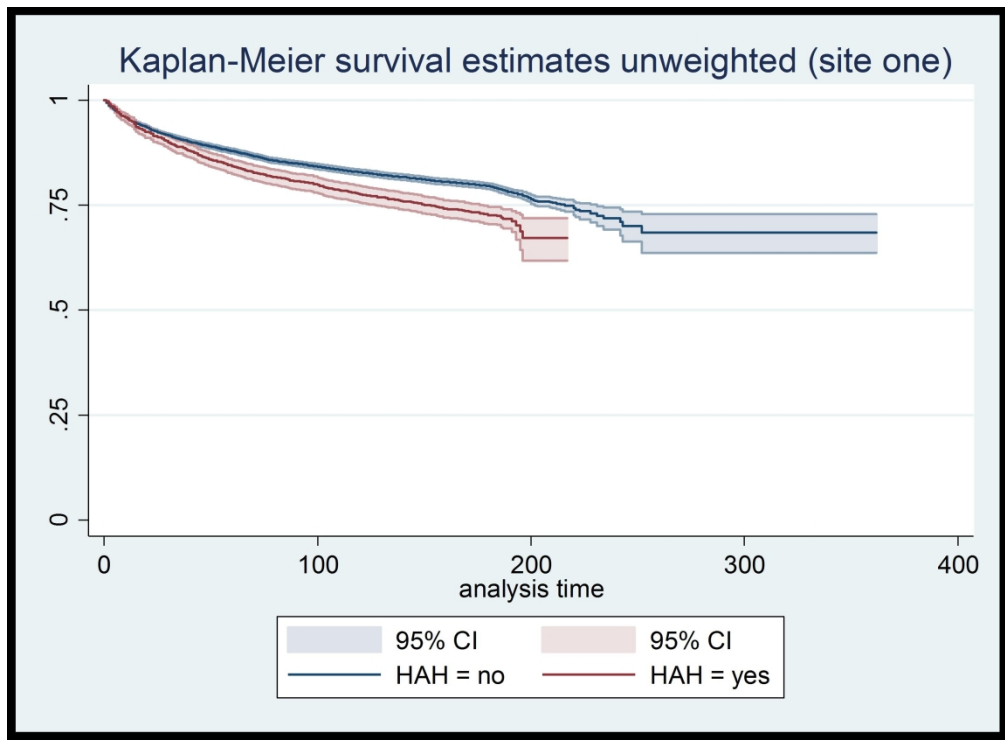


Figure 3. Survival curves before and after propensity score matching



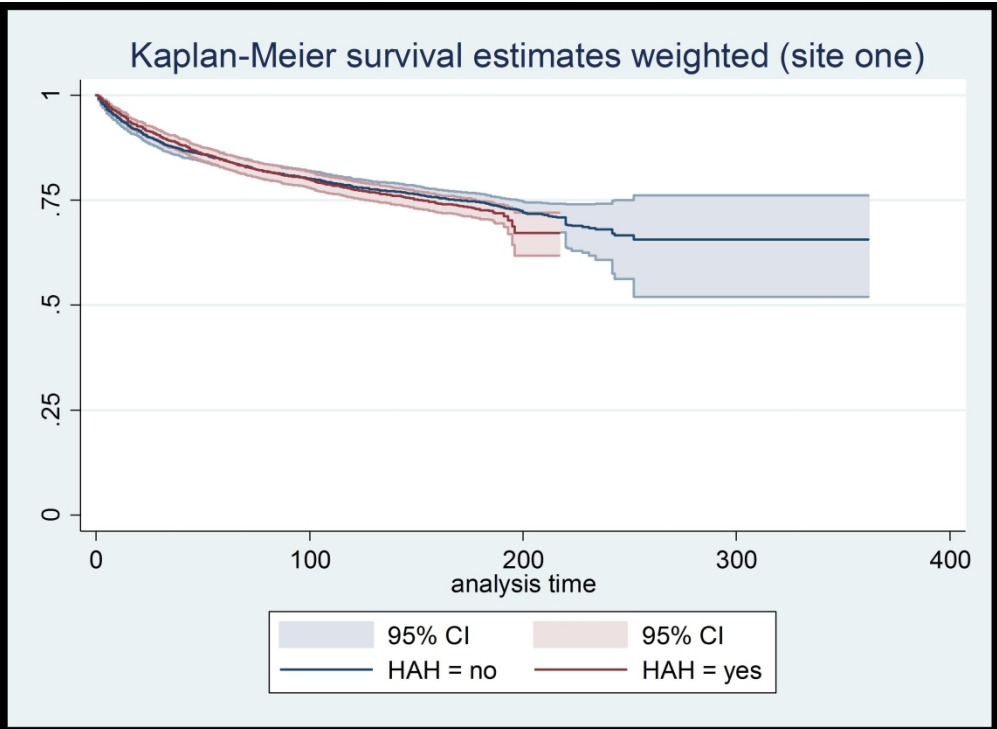
Note: The cohorts in each site were matched on age, gender, socio-economic status, primary and secondary ICD-10 codes of index admission, type of long-term condition, 2-year costs prior to the index admission (by cost category as listed in Box 1); Weighted refers to weighting the observation of each patient based on the propensity score to be in the hospital-at-home cohort as described in the propensity score matching section.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



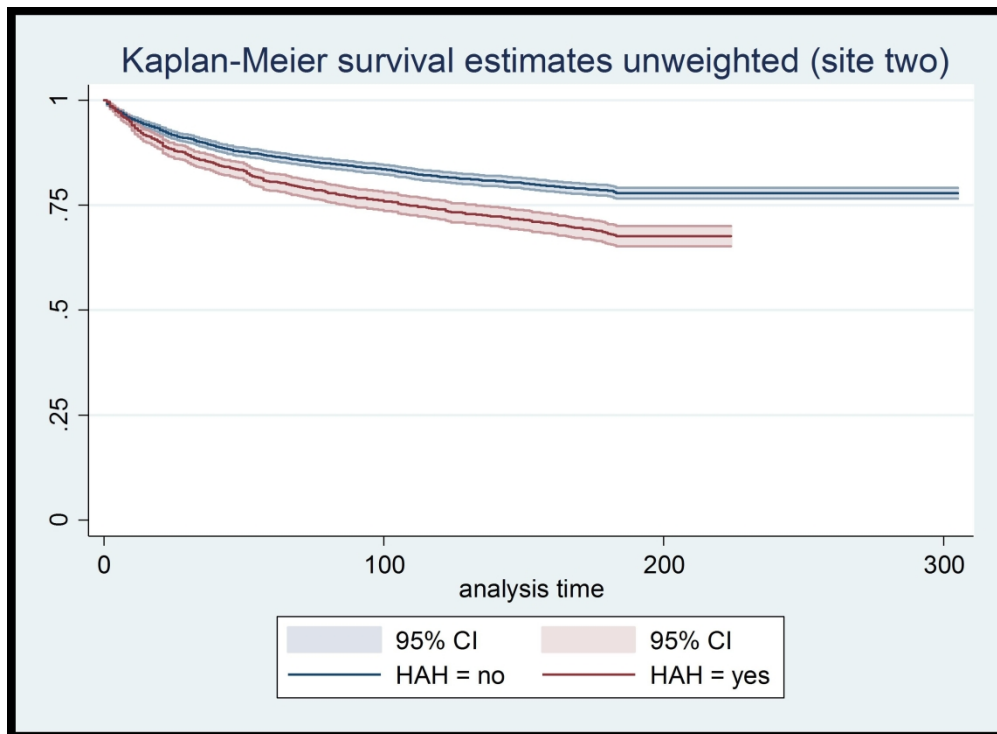
886x649mm (96 x 96 DPI)

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



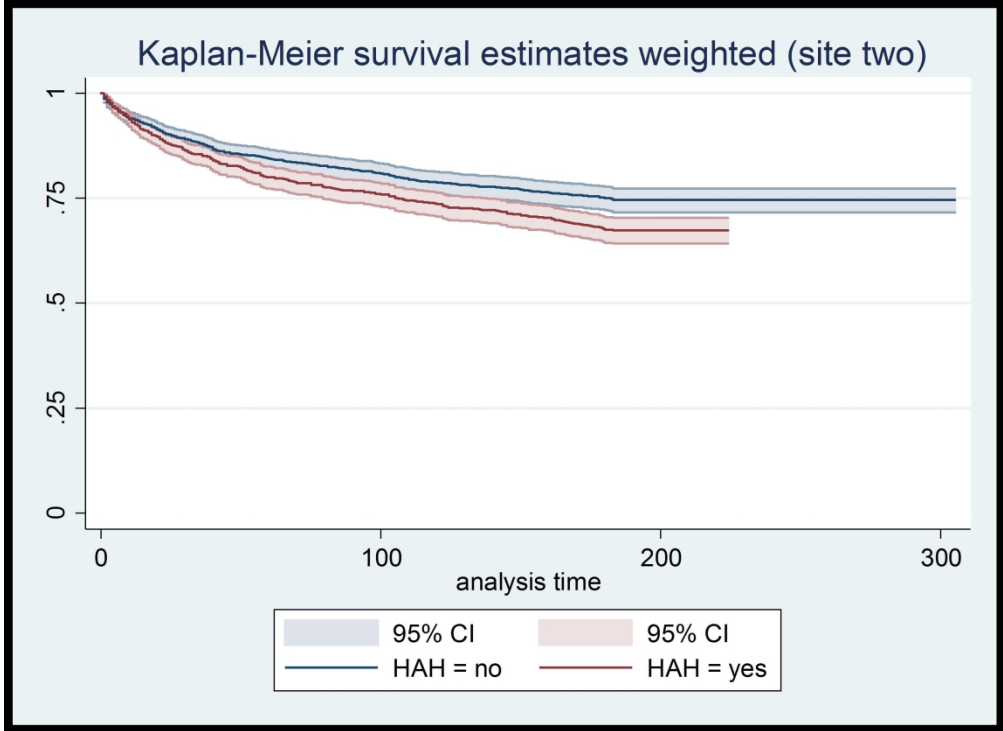
886x649mm (96 x 96 DPI)

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



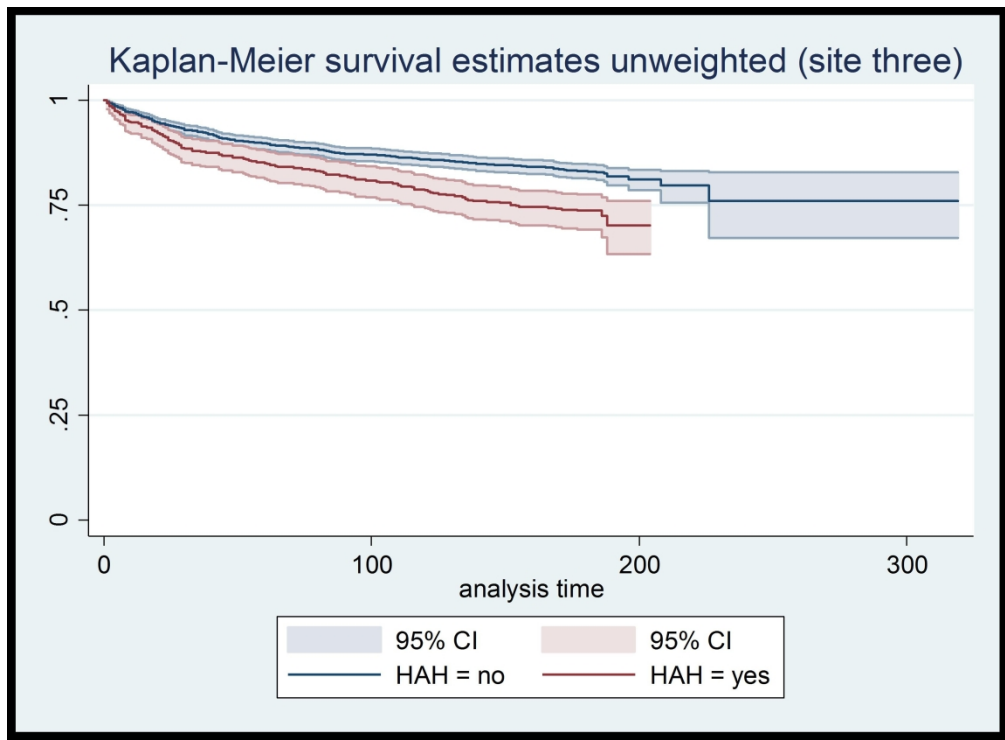
886x649mm (96 x 96 DPI)

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



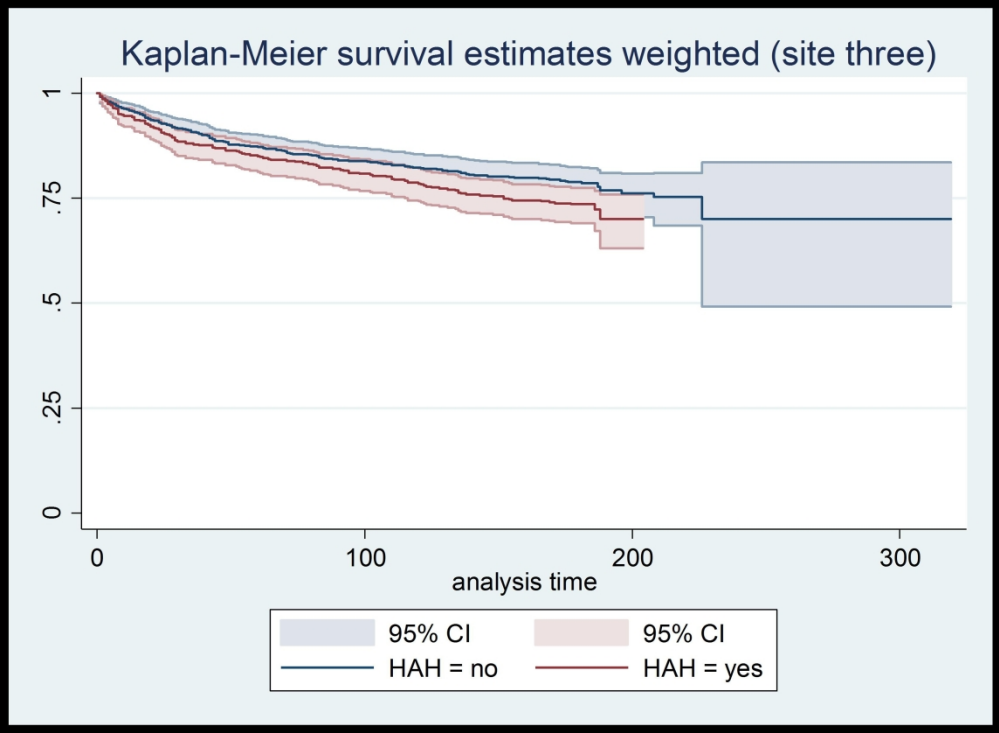
886x649mm (96 x 96 DPI)

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



886x649mm (96 x 96 DPI)

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



886x649mm (96 x 96 DPI)

## Appendix 1. Calculation of admission avoidance hospital-at-home in each site

Site one		PERIOD				
	from: 01/08/2014 (dd/mm/yyyy)		Until: 01/01/2016 (dd/mm/yyyy)		17 Months	
Number of HAH admissions (in period)	1771		Source of ISD IPD data (1/8/14-31/12/15)			
Length of HAH stay per episode (in)	5.53886 0.125605	Mean Standard error	ISD IPD data (1/8/14-31/12/15)			
HAH bed days (period)	9809					
<b>A.1. Staff costs</b>						
N	Profession	WTEs	Gross	Summary salary	Source of	Total
a)	Medical staff					
1	Consultant	1.50	£151,596		Business	£227,394
2	Agency consultant	0.16	£156,926		Business	£25,651
3	Consultant	1.07	£119,710		Business	£127,767
b)	Nursing and pharmacy services					
1	Band 3 nurse	3.00	£24,790		Business	£74,369
2	Band 6 nurse	1.49	£41,425		Business	£61,740
3	Band 5 Bank nurse	0.71	£32,885		Business	£23,399
4	Band 6 Bank nurse	0.36	£38,471		Business	£13,687
5	Band 7 pharmacist	0.71	£55,491		Business	£39,484
6	Band 5 nurse	0.16	£37,036		Business	£6,054
7	Band 6 nurse	1.42	£42,342		Business	£60,303
8	Band 7 nurse	1.00	£42,444		Business	£42,444
9	Band 8a nurse	0.71	£53,126		Business	£37,801
c)	Allied health professions					
1	Band 6 occupational therapist	2.59	£35,489		Business	£91,793
2	Band 6 physiotherapist	1.16	£46,585		Business	£54,200
3	Band 4 assistant practitioners for rehab	3.59	£24,660		Business	£88,444
4	Band 6 physiotherapy	0.71	£46,848		Business	£33,334
d)	Administration, ICT and management					
1	Band 2 admin/clerical	0.30	£19,346		Business	£5,804
2	Band 3 admin/clerical	1.00	£23,948		Business	£23,948
3	Band 3 admin/clerical	0.71	£21,353		Business	£15,193
e)	Support services staff					
1						£0
	<b>Total</b>					<b>£1,052,80</b>
<b>A.2. Training costs</b>						
Note: the time to attend a course should be included in						
No.	Profession	Number of	Cost per	Summary costs	Source of	Total
1	Acute urgent care course	20	£250			£5,000
2	Prescribing course	3	£310			£930
	<b>Total</b>					<b>£5,930</b>
<b>A.3. Transport costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Travel and subsistence			£37,918	Business	£37,918
	<b>Total</b>					<b>£37,918</b>
<b>A.4. Information and communication costs</b>						
(e.g. brochures and leaflets for patients and their						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1						£0
	<b>Total</b>					<b>£0</b>
<b>A.5. Clinical materials/equipment and drugs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Instruments and sundries			£2,867	Business	£2,867



2	Equipment repairs clinical			£585	Business	£585
3	Surgical appliances			£104	Business	£104
4	Drugs			£1,693	Business	£1,693
5	Equipment purchase clinical			£298	Business	£298
	<b>Total</b>					<b>£5,546</b>
<b>A.6.</b>	<b>Support services supplies</b>					
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Catering			£177	Business	£177
2	Uniforms			£552	Business	£552
3	Printing and stationery			£737	Business	£737
4	Dressings			£473	Business	£473
5	general services			£16	Business	£16
	<b>Total</b>					<b>£1,955</b>
<b>A.7.</b>	<b>Labs and diagnostics</b>					
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Diagnostic supplies			£559	Business	£559
	<b>Total</b>					<b>£559</b>
<b>A.8.</b>	<b>Overhead costs</b>					
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Telephone			£3,794	Business	£3,794
2	Building			£119	Business	£119
3	Miscellaneous			£34	Business	£34
	<b>Total</b>					<b>£3,947</b>
<b>A.9.</b>	<b>Other costs</b>					
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Equipment purchase non medical			£3,354	Business	£3,354
2	postage			£772	Business	£772
	<b>Total</b>					<b>£4,126</b>
<b>A.10</b>	<b>Additional costs</b>					
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1						£0
	<b>Total</b>					<b>£0</b>
					<b>TOTAL</b>	<b>£1,112,79</b>
				<b>Unit cost of HAH admission</b>		<b>£628.34</b>
				<b>Unit cost of HAH bed day</b>		<b>£113.44</b>

Site two		PERIOD					
		from:	01/01/2015 (dd/mm/yyyy)	Until:	01/01/2017 (dd/mm/yyyy)	24 Months	
				Source of			
Number of HAH admissions (in period)		1547		ISD IPD data			
Length of HAH stay per episode (in		7.35 Mean		ISD IPD data			
		0.14 Standard error					
HAH bed days (period)		11376					
<b>A.1. Staff costs</b>							
N	Profession	WTEs	Gross	Summary salary	Source of	Total	
<b>a) Medical staff</b>							
1	Senior medical			£82,099	Business	£82,099	
2	Professional fees and charges			£124,391	Business	£124,391	
<b>b) Nursing and pharmacy services</b>							
1	Nursing & Midwifery-trained			£2,904,576	Business	£2,904,576	
2	Nursing & Midwifery-untrained			£627,532	Business	£627,532	
3	Pharmacists			£43,715	Business	£43,715	
4	Pharmacy Technicians			£14,471	Business	£14,471	
<b>c) Allied health professions</b>							
1					Business	£0	
<b>d) Administration, ICT and management</b>							
1	Admin Clerical			£126,018	Business	£126,018	
<b>e) Support services staff</b>							
1						£0	
<b>Total</b>						<b>£3,922,80</b>	
<b>A.2. Training costs</b>							
Note: the time to attend a course should be included in							
No.	Profession	Number of	Cost per	Summary costs	Source of	Total	
1	Training costs			£1,512		£1,512	
<b>Total</b>						<b>£1,512</b>	
<b>A.3. Transport costs</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total	
1	Transport			£25,711	Business	£25,711	
2	Travel And Subsistence			£340,388		£340,388	
<b>Total</b>						<b>£366,099</b>	
<b>A.4. Information and communication costs</b>							
(e.g. brochures and leaflets for patients and their							
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total	
1						£0	
<b>Total</b>						<b>£0</b>	
<b>A.5. Clinical materials/equipment and drugs</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total	
1	Drugs			£203,900	Business	£203,900	
2	Equipment			£14,589	Business	£14,589	
3	Paramedical Supplies			£3,015	Business	£3,015	
4	Surgical Appliances			£18	Business	£18	
5	Surgical Sundries			£80,855	Business	£80,855	
<b>Total</b>						<b>£302,377</b>	
<b>A.6. Support services supplies</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total	
1	Bedding And Linen			£112	Business	£112	
2	Cleaning			£8,251	Business	£8,251	
3	General Services			£2,595		£2,595	
<b>Total</b>						<b>£10,958</b>	
<b>A.7. Labs and diagnostics</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total	
1	Cssd/diagnostic Supplies			£3,783		£3,783	

							£3,783
<b>A.8.</b>	<b>Overhead costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of		<b>Total</b>
1	Post Carriage And Telephones			£5,224			£5,224
2	Printing And Stationery			£5,737	Business		£5,737
3	Property Maintenance			£1,174			£1,174
4	Miscellaneous			£25	Business		£25
	<b>Total</b>						<b>£12,160</b>
<b>A.9.</b>	<b>Other costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of		<b>Total</b>
1	Provisions			£6	Business		£6
2	Uniforms			£334	Business		£334
	<b>Total</b>						<b>£340</b>
<b>A.10</b>	<b>Additional costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of		<b>Total</b>
1	Other Operating Income**			-£92,377			-£92,377
	<b>Total</b>						<b>-£92,377</b>
					<b>TOTAL</b>		<b>£4,527,65</b>
					<b>Unit cost of HAH admission</b>		<b>£2,926.73</b>
					<b>Unit cost of HAH bed day</b>		<b>£398.01</b>

Site three							
	from:	01/01/2015 (dd/mm/yyyy)	PERIOD Until:	01/01/2016 (dd/mm/yyyy)	12 Months		
			Source	of			
Number of HAH admissions (in period)	598		ISD IPD data				
	598		business case				
Length of HAH stay per episode (in days)	7.35	Mean	ISD IPD data				
	0.14	Standard error					
HAH bed days (period)	4397						
<b>A.1. Staff costs</b>							
No.	Profession	WTEs	Gross annual	Summary salary cost	Source	of	Total
<b>a) Medical staff</b>							
1	Consultant	1		£114,776	Business		£114,77
2	Specialty doctor	1		£79,224	Business		£79,224
3					Business		£0
4							£0
5							£0
<b>b) Nursing and pharmacy services</b>							
1	Nurse (Band 6)	3		£125,484	Business		£125,48
2	Nurse (Band 5)	1.6		£53,256	Business		£53,256
<b>c) Allied health professions</b>							
1	Occupational therapist	1		£45,156	Business		£45,156
2	Physiotherapist	1		£45,156	Business		£45,156
<b>d) Administration, ICT and management</b>							
1	Admin Clerical	1		£23,664	Business		£23,664
<b>e) Support services staff</b>							
1							£0
<b>Total</b>							<b>£486,71</b>
<b>A.2. Training costs</b>							
Note: the time to attend a course should be included in							
No.	Profession	Number of	Cost per	Summary costs	Source	of	Total
1	Training costs			£1,000			£1,000
<b>Total</b>							<b>£1,000</b>
<b>A.3. Transport costs</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1	Transport/travel			£20,000	Business		£20,000
<b>Total</b>							<b>£20,000</b>
<b>A.4. Information and communication costs</b>							
(e.g. brochures and leaflets for patients and their family)							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1							£0
<b>Total</b>							<b>£0</b>
<b>A.5. Clinical materials/equipment and drugs</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1	Drugs			£4,840	Business		£4,840
2	Medical supplies			£2,393	Business		£2,393
<b>Total</b>							<b>£7,233</b>
<b>A.6. Support services supplies</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1							£0
<b>Total</b>							<b>£0</b>
<b>A.7. Labs and diagnostics</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1							£0
<b>Total</b>							<b>£0</b>
<b>A.8. Overhead costs</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total

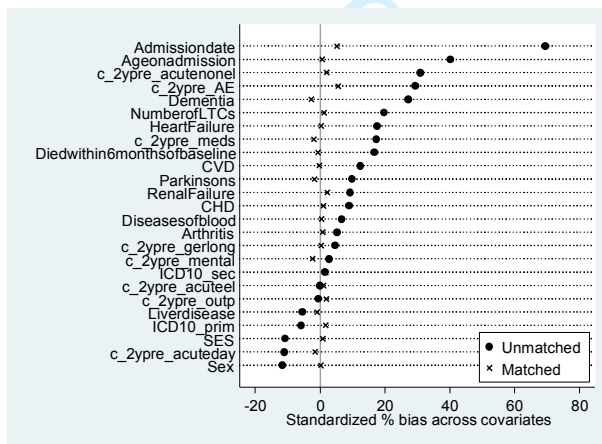
1	Phones, stationary etc.			£1,796	Business		£1,796
	<b>Total</b>						<b>£1,796</b>
<b>A.9. Other costs</b>							
No.	Cost item	Number	of	Cost per item	Summary costs	Source	of Total
1	Miscellaneous				£250		£250
	<b>Total</b>						<b>£250</b>
<b>A.10 Additional costs</b>							
No.	Cost item	Number	of	Cost per item	Summary costs	Source	of Total
1							£0
	<b>Total</b>						<b>£0</b>
						<b>TOTAL</b>	<b>£516,99</b>
						Unit cost of HAH admission	<b>£864.54</b>
						Unit cost of HAH bed day	<b>£117.57</b>

Appendix 2 Results of selecting PSM technique and plots of covariance balance before and after propensity score matching

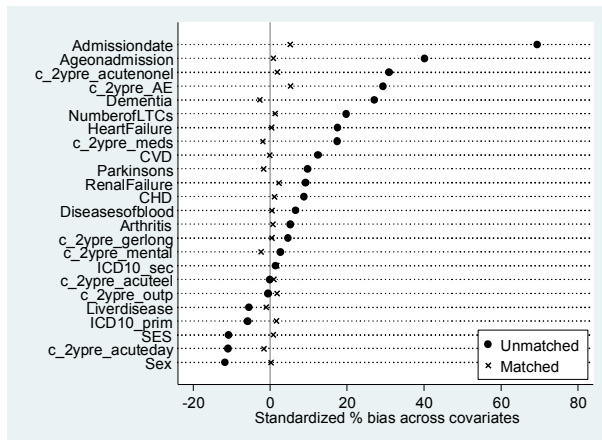
Variable	Site one		Site two		Site three	
	Costs	Survival	Costs	Survival	Costs	Survival
	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R
Mahalanobis	7.5/4.2;51.4/1.56	7.2/3.7;48.6/1.54	7.6/6.7;46.1/1.54	7.3/6.7;43.9/1.53	6.3/4.7/38.4/1.69	6.3/3.5/38.4/1.52
1-to-1	2.9/2.8;14.1/0.90	1.9/1.6;12.1/0.84	1.4/1.4;9.4/0.97	2.2/2.2;14.6/1.14	2.7/2.7/14.6/1.02	2.3/2.6/14.9/0.73
K-to-1	1.9/1.6;11.3/0.76	1.9/1.5;12.0/0.81	1.8/1.5;11.0/0.83	2.4/2.4;13.6/0.76	3.6/2.9/16.5/0.99	2.8/2.0/16.5/0.94
Kernel	1.6/1.1;9.8/0.97	1.5/1.2;8.9/0.92	1.1/0.9;6.9/1.02	0.9/0.7;6.5/1.01	2.2/1.6/12.3/1.22	1.9/1.2/11.2/1.21
Local linear regression	1.5/1.2;9.4/0.89	1.6/1.4;9.4/0.89	1.7/1.0;11.0/0.32	2.3/1.4;12.8/0.43	1.8/1.6/9.6/1.27	1.6/1.2/8.5/1.35
Spline	2.9/2.6;15.7/0.94	2.4/2.0;14.9/0.91	3.2/2.6;17.5/0.46	3.2/2.3;21.0/1.07	3.9/3.1/21.6/0.47	3.9/2.3/25.7/1.02
IPW	11.5/5.8;83.2/0.76	11.5/5.6;83.1/0.75	11.6/8.3;61.3/0.92	11.2/7.8;60.2/0.89	10.5/8.5/52.2/0.77	10.2/8.5/50.9/0.77

Rubin's B: the absolute standardized difference of the means of the linear index of the propensity score in the treated and (matched) non-treated group; Rubin's R: the ratio of treated to (matched) non-treated variances of the propensity score index; Samples sufficiently balanced if B less than 25 and that R between 0.5 and 2.

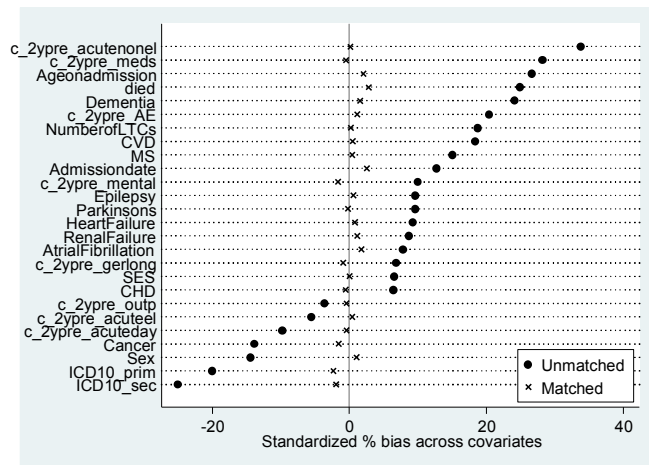
Standardised percentage bias before and after local linear regression propensity score matching for costs in site one



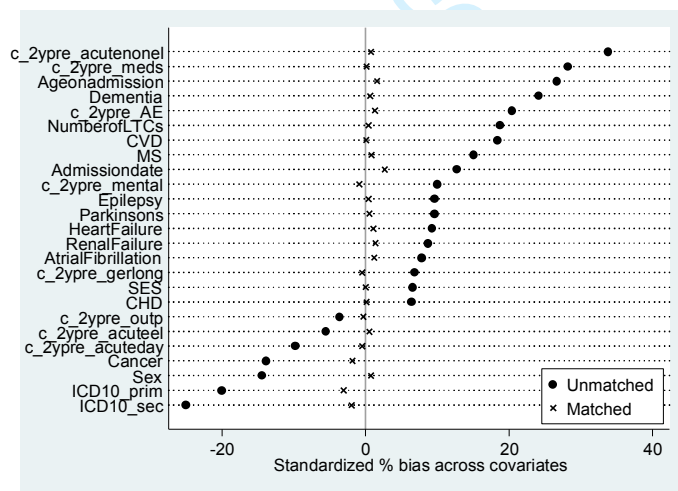
Standardised percentage bias before and after local linear regression propensity score matching for survival in site one



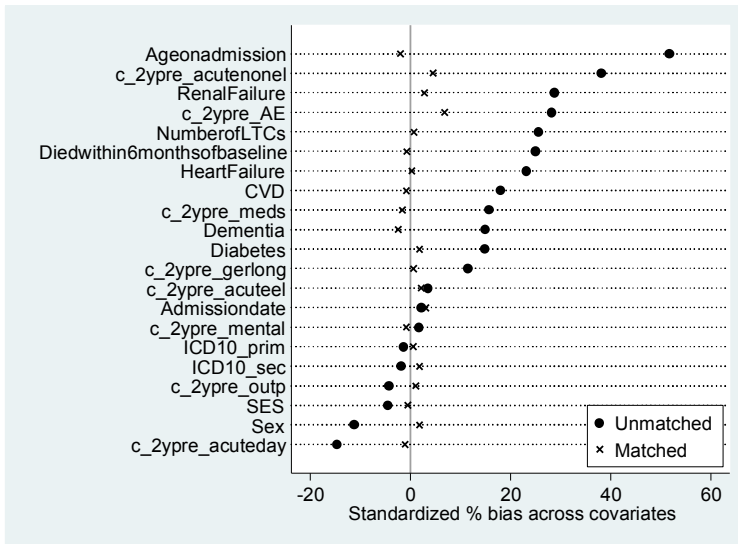
Standardised percentage bias before and after Kernel propensity score matching for costs in site two



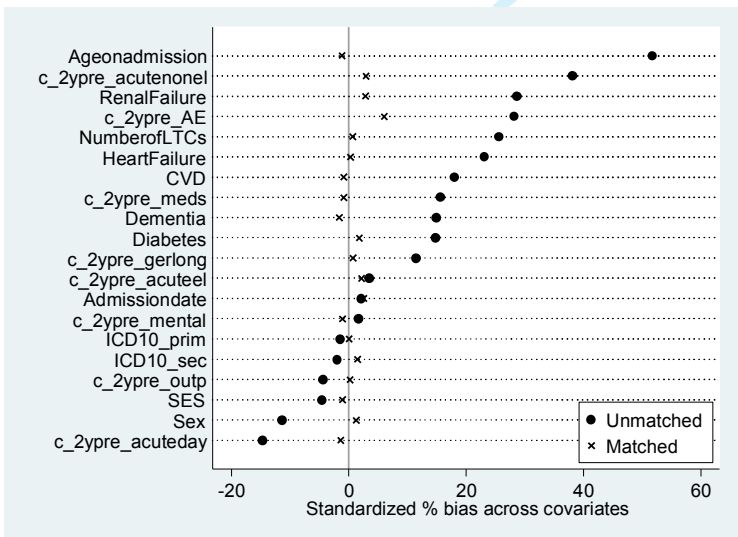
Standardised percentage bias before and after Kernel propensity score matching for survival in site two



Standardised percentage bias before and after local linear regression propensity score matching for costs in site three

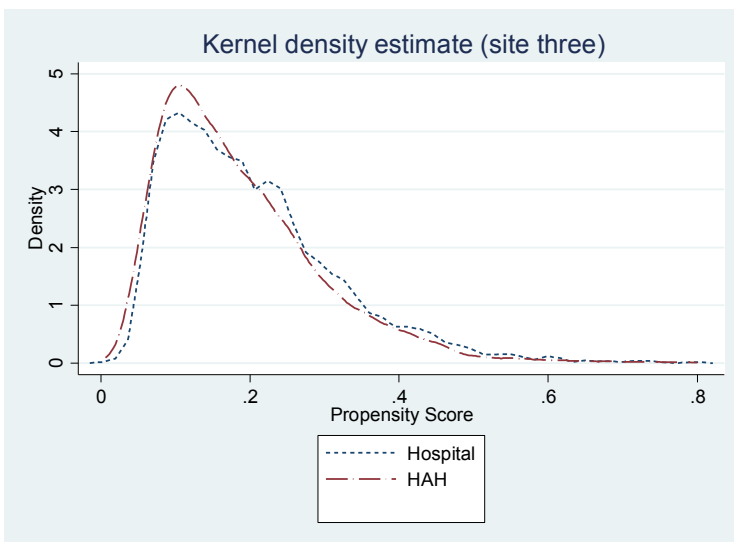
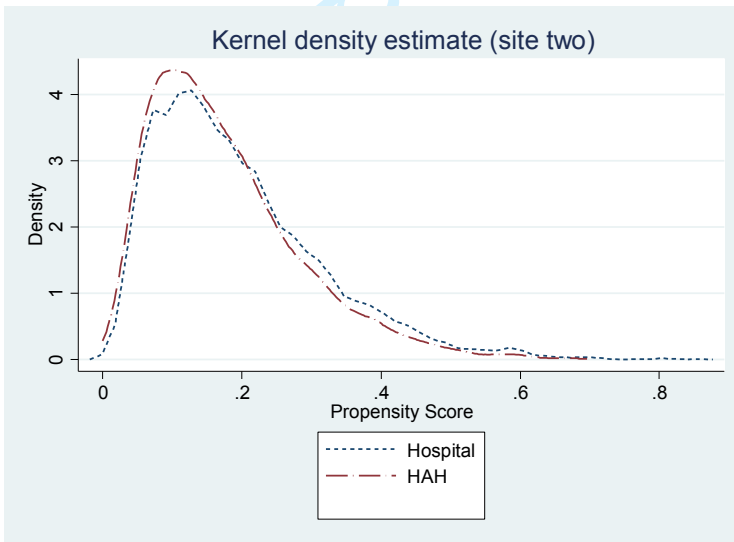
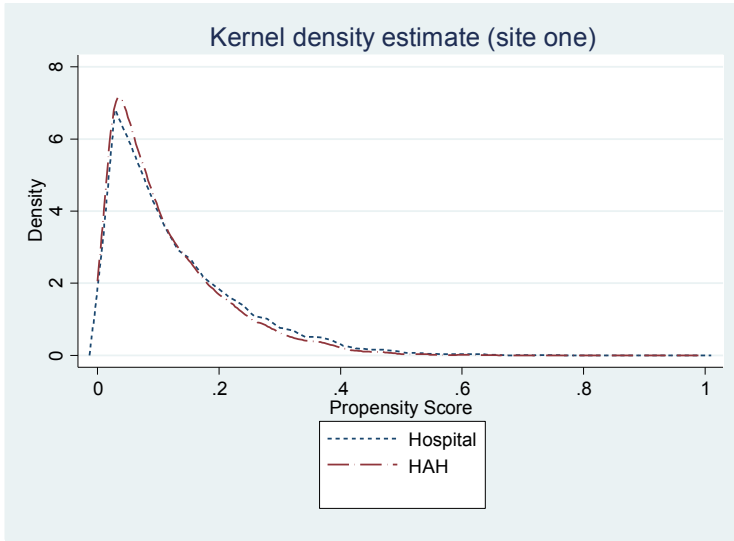


Standardised percentage bias before and after local linear regression propensity score matching for survival in site three





Propensity score distributions by cohort in each site



Appendix 3. Full results of the regression analyses

Association of hospital at home with total costs (after propensity score matching)

	site one (n=13,267)		site two (n=4,769)		site three (n=2110)	
	Follow-up period coefficient (se) [95%CI] p value	6 months after discharge coefficient (se) [95%CI] p value	Follow-up period coefficient (se) [95%CI] p value	6 months after discharge coefficient (se) [95%CI] p value	Follow-up period coefficient (se) [95%CI] p value	6 months after discharge coefficient (se) [95%CI] p value
HAH	0.82 (0.03) [0.76;0.89] <0.001	1.27 (0.07) [1.14;1.41] <0.001	1.00 (0.05) [0.92;1.09] 0.982	1.09 (0.07) [0.95;1.24] 0.219	1.15 (0.09) [0.99;1.33] 0.073	1.70 (0.17) [1.4;2.07] <0.001
Admission date	1.00 (0.00) [1.00;1.00] 0.058	1.00 (0.00) [1.00;1.00] 0.009	1.00 (0.00) [1.00;1.00] 0.386	1.00 (0.00) [1.00;1.00] 0.824	1.00 (0.00) [1.00;1.00] 0.009	1.00 (0.00) [1.00;1.00] 0.056
ICD10 primary	1.00 (0.00) [1.00;1.00] 0.660	1.00 (0.00) [1.00;1.00] 0.230	1.00 (0.00) [1.00;1.00] 0.001	1.00 (0.00) [1.00;1.00] <0.001	1.00 (0.00) [1.00;1.00] 0.162	1.00 (0.00) [1.00;1.00] 0.101
ICD10 secondary	1.00 (0.00) [1.00;1.00] 0.641	1.00 (0.00) [1.00;1.00] 0.988	1.00 (0.00) [1.00;1.00] 0.146	1.00 (0.00) [1.00;1.00] 0.238	1.00 (0.00) [1.00;1.00] 0.897	1.00 (0.00) [1.00;1.00] 0.971
2yrs pre AE costs	1.00 (0.00) [1.00;1.00] 0.240	1.00 (0.00) [1.00;1.00] 0.018	1.00 (0.00) [1.00;1.00] 0.624	1.00 (0.00) [1.00;1.00] 0.309	1.00 (0.00) [1.00;1.00] 0.284	1.00 (0.00) [1.00;1.00] 0.42
2yrs pre elective costs	1.00 (0.00) [1.00;1.00] 0.906	1.00 (0.00) [1.00;1.00] 0.919	1.00 (0.00) [1.00;1.00] 0.588	1.00 (0.00) [1.00;1.00] 0.435	1.00 (0.00) [1.00;1.00] 0.865	1.00 (0.00) [1.00;1.00] 0.931
2yrs pre non-elective costs	1.00 (0.00) [1.00;1.00] <0.001	1.00 (0.00) [1.00;1.00] 0.001	1.00 (0.00) [1.00;1.00] 0.694	1.00 (0.00) [1.00;1.00] 0.697	1.00 (0.00) [1.00;1.00] 0.018	1.00 (0.00) [1.00;1.00] 0.015
2yrs pre day case costs	1.00 (0.00) [1.00;1.00] 0.098	1.00 (0.00) [1.00;1.00] 0.020	1.00 (0.00) [1.00;1.00] 0.005	1.00 (0.00) [1.00;1.00] <0.001	1.00 (0.00) [1.00;1.00] 0.14	1.00 (0.00) [1.00;1.00] 0.100
2yrs pre geriatric ward costs	1.00 (0.00) [1.00;1.00] 0.005	1.00 (0.00) [1.00;1.00] 0.054	1.00 (0.00) [1.00;1.00] 0.001	1.00 (0.00) [1.00;1.00] 0.003	1.00 (0.00) [1.00;1.00] 0.634	1.00 (0.00) [1.00;1.00] 0.342
2yrs pre mental ward costs	1.00 (0.00) [1.00;1.00] 0.880	1.00 (0.00) [1.00;1.00] 0.911	1.00 (0.00) [1.00;1.00] 0.009	1.00 (0.00) [1.00;1.00] 0.014	1.00 (0.00) [1.00;1.00] 0.111	1.00 (0.00) [1.00;1.00] 0.382
2yrs pre outpatient costs	1.00 (0.00) [1.00;1.00] 0.087	1.00 (0.00) [1.00;1.00] 0.056	1.00 (0.00) [1.00;1.00] 0.026	1.00 (0.00) [1.00;1.00] 0.043	1.00 (0.00) [1.00;1.00] 0.683	1.00 (0.00) [1.00;1.00] 0.656
2yrs pre medication costs	1.00 (0.00) [1.00;1.00] 0.798	1.00 (0.00) [1.00;1.00] 0.750	1.00 (0.00) [1.00;1.00] 0.172	1.00 (0.00) [1.00;1.00] 0.369	1.00 (0.00) [1.00;1.00] 0.687	1.00 (0.00) [1.00;1.00] 0.935
Died during follow-up	1.03 (0.04) [0.95;1.11] 0.530	0.91 (0.05) [0.82;1.01] 0.089	1.05 (0.05) [0.96;1.15] 0.302	0.90 (0.06) [0.78;1.05] 0.143	1.06 (0.09) [0.90;1.24] 0.498	0.97 (0.11) [0.78;1.21] 0.784
Number of LTCs	1.09 (0.02) [1.05;1.12] <0.001	1.12 (0.02) [1.07;1.16] <0.001	1.04 (0.02) [1.00;1.07] 0.054	1.06 (0.03) [1.00;1.11] 0.035	1.06 (0.03) [1.01;1.11] 0.017	1.10 (0.03) [1.03;1.17] 0.003
Age on admission	1.00 (0.00) [0.99;1.01] 0.383	1.00 (0.00) [0.99;1.01] 0.981	1.00 (0.00) [0.99;1.01] 0.984	1.00 (0.00) [1.00;1.00] 0.349	1.01 (0.01) [1.00;1.02] 0.045	1.01 (0.01) [0.99;1.02] 0.41
Male	1.09 (0.05) [1.01;1.19] 0.034	1.08 (0.06) [0.97;1.19] 0.136	0.95 (0.05) [0.86;1.05] 0.340	0.99 (0.08) [0.85;1.15] 0.859	0.97 (0.08) [0.83;1.13] 0.709	0.98 (0.10) [0.81;1.2] 0.875
SES	1.00 (0.01) [0.98;1.02] 0.988	1.00 (0.01) [0.98;1.03] 0.741	1.01 (0.01) [1.00;1.03] 0.182	1.03 (0.01) [1.00;1.05] 0.033	1.00 (0.02) [0.97;1.03] 0.899	1.01 (0.02) [0.97;1.05] 0.779
Arthritis	0.96 (0.04) [0.88;1.05] 0.398	0.95 (0.05) [0.85;1.06] 0.346	-----	-----	-----	-----
Atrial Fibrillation	-----	-----	1.09 (0.06) [0.98;1.2] 0.098	1.13 (0.08) [0.97;1.30] 0.113	-----	-----
Cancer	-----	-----	1.04 (0.05) [0.94;1.15] 0.485	1.07 (0.08) [0.92;1.24] 0.403	-----	-----
CVD	1.01 (0.06) [0.91;1.13] 0.767	0.99 (0.07) [0.86;1.13] 0.903	1.08 (0.06) [0.97;1.2] 0.168	1.11 (0.09) [0.95;1.29] 0.199	1.10 (0.11) [0.90;1.34] 0.339	1.07 (0.13) [0.84;1.37] 0.585
Liver disease	1.21 (0.13) [0.98;1.50] 0.074	1.20 (0.14) [0.95;1.51] 0.130	-----	-----	-----	-----
Dementia	1.06 (0.05) [0.97;1.17] 0.179	1.07 (0.07) [0.95;1.21] 0.236	1.00 (0.05) [0.91;1.11] 0.942	1.03 (0.08) [0.89;1.19] 0.683	1.14 (0.11) [0.95;1.38] 0.166	1.17 (0.15) [0.91;1.5] 0.211
Epilepsy	-----	-----	1.04 (0.11) [0.85;1.27] 0.734	1.04 (0.15) [0.78;1.38] 0.803	-----	-----
CHD	0.85 (0.05) [0.77;0.95] 0.004	0.83 (0.06) [0.73;0.95] 0.008	1.01 (0.06) [0.9;1.13] 0.871	1.02 (0.08) [0.88;1.20] 0.766	-----	-----
Heart Failure	1.09 (0.06) [0.98;1.20] 0.102	1.10 (0.07) [0.97;1.24] 0.154	1.08 (0.06) [0.96;1.21] 0.186	1.08 (0.09) [0.92;1.28] 0.363	1.01 (0.10) [0.83;1.23] 0.919	0.98 (0.13) [0.76;1.26] 0.879
Multiple sclerosis	-----	-----	0.74 (0.10) [0.57;0.98] 0.033	0.59 (0.15) [0.36;0.97] 0.035	-----	-----
Parkinson's	1.24 (0.11) [1.03;1.48] 0.019	1.20 (0.14) [0.95;1.51] 0.120	1.09 (0.15) [0.83;1.42] 0.554	1.09 (0.20) [0.75;1.57] 0.664	-----	-----
Renal Failure	1.03 (0.05) [0.94;1.13] 0.513	1.06 (0.06) [0.94;1.19] 0.362	1.05 (0.06) [0.94;1.17] 0.420	1.08 (0.09) [0.92;1.26] 0.348	1.12 (0.12) [0.9;1.38] 0.306	1.14 (0.16) [0.87;1.49] 0.346
Diseases of blood	1.05 (0.05) [0.96;1.15] 0.275	1.05 (0.06) [0.94;1.18] 0.363	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	1.21 (0.11) [1.01;1.45] 0.043	1.24 (0.14) [0.99;1.55] 0.061
Constant	15.93 (46.90) [0.05;5098.92] 0.347	0.19 (0.68) [0.00;224.04] 0.644	285486.5 (1267507) [47.47; 1.72E+09] 0.005	899.53 (5743.23) [0.00;0.00] 0.287	20700000000000 (18600000000000) [500612.1;8.6E+20] 0.001	2230000000000 (25100000000000) [559.85;8.85E+21] 0.012

# driven mainly by non-elective hospital care; Note the HAH unit costs in site one were £628.34 per admission to HAH and have been added to the costs during the episode.

## Association of hospital-at-home with mortality risk during study period (after propensity score matching)

	site one (n=13,267)				site two (n=4,771)				site three (n=2110)			
	coefficient	(se)	[95%CI]	p value	coefficient	(se)	[95%CI]	p value	coefficient	(se)	[95%CI]	p value
HAH	1.09	(0.05)	[1.00;1.19]	0.059	1.29	(0.07)	[1.15;1.44]	<0.0010	1.27	(0.12)	[1.06;1.54]	0.011
Admission date	1.00	(0.00)	[1.00;1.00]	0.842	1.00	(0.00)	[1.00;1.00]	0.100	1	(0)	[1;1]	0.687
ICD10 primary	1.00	(0.00)	[1.00;1.00]	<0.001	1.00	(0.00)	[1.00;1.00]	0.001	1	(0)	[1;1]	0.006
ICD10 secondary	1.00	(0.00)	[1.00;1.00]	<0.001	1.00	(0.00)	[1.00;1.00]	0.023	1	(0)	[1;1]	0.359
2yrs pre AE costs	1.00	(0.00)	[1.00;1.00]	0.640	1.00	(0.00)	[1.00;1.00]	0.153	1	(0)	[1;1]	0.027
2yrs pre elective costs	1.00	(0.00)	[1.00;1.00]	0.487	1.00	(0.00)	[1.00;1.00]	0.462	1	(0)	[1;1]	0.079
2yrs pre non-elective costs	1.00	(0.00)	[1.00;1.00]	0.001	1.00	(0.00)	[1.00;1.00]	0.007	1	(0)	[1;1]	0.052
2yrs pre day case costs	1.00	(0.00)	[1.00;1.00]	<0.001	1.00	(0.00)	[1.00;1.00]	0.001	1	(0)	[1;1]	0.903
2yrs pre geriatric ward costs	1.00	(0.00)	[1.00;1.00]	0.022	1.00	(0.00)	[1.00;1.00]	<0.001	1	(0)	[1;1]	0.338
2yrs pre mental ward costs	1.00	(0.00)	[1.00;1.00]	0.419	1.00	(0.00)	[1.00;1.00]	0.943	1	(0)	[1;1]	0
2yrs pre outpatient costs	1.00	(0.00)	[1.00;1.00]	0.091	1.00	(0.00)	[1.00;1.00]	0.882	1	(0)	[1;1]	0.001
2yrs pre medication costs	1.00	(0.00)	[1.00;1.00]	0.044	1.00	(0.00)	[1.00;1.00]	0.037	1	(0)	[1;1]	0
Number of LTCs	1.03	(0.02)	[0.99;1.07]	0.120	0.96	(0.02)	[0.92;1.01]	0.107	1.07	(0.04)	[1;1.14]	0.048
Age on admission	1.04	(0)	[1.03;1.04]	<0.001	1.03	(0.00)	[1.02;1.04]	<0.001	1.04	(0.01)	[1.02;1.05]	0
Male	1.12	(0.05)	[1.01;1.22]	0.017	1.23	(0.08)	[1.09;1.39]	0.001	1.37	(0.14)	[1.12;1.67]	0.002
SES	0.97	(0.01)	[0.95;0.99]	0.001	0.98	(0.01)	[0.96;1.00]	0.088	1.01	(0.02)	[0.98;1.05]	0.483
Arthritis	0.86	(0.05)	[0.77;0.97]	0.008	-----	-----	-----	-----	-----	-----	-----	-----
Atrial Fibrillation	-----	-----	-----	-----	1.11	(0.08)	[0.97;1.28]	0.133	-----	-----	-----	-----
Cancer	-----	-----	-----	-----	1.86	(0.12)	[1.64;2.11]	<0.001	-----	-----	-----	-----
CVD	0.94	(0.06)	[0.83;1.05]	0.276	1.06	(0.08)	[0.92;1.22]	0.438	0.95	(0.12)	[0.74;1.21]	0.673
Liver disease	1.33	(0.16)	[1.04;1.67]	0.015	-----	-----	-----	-----	-----	-----	-----	-----
Dementia	1.11	(0.06)	[1.00;1.25]	0.058	1.59	(0.11)	[1.39;1.82]	<0.001	1.31	(0.16)	[1.03;1.67]	0.025
Epilepsy	-----	-----	-----	-----	1.19	(0.17)	[0.91;1.57]	0.207	-----	-----	-----	-----
CHD	0.91	(0.05)	[0.82;1.03]	0.114	0.93	(0.07)	[0.80;1.08]	0.345	-----	-----	-----	-----
Heart Failure	1.13	(0.07)	[1.00;1.28]	0.052	1.35	(0.11)	[1.15;1.57]	<0.001	1.16	(0.15)	[0.9;1.5]	0.256
Multiple sclerosis	-----	-----	-----	-----	1.54	(0.39)	[0.94;2.52]	0.086	-----	-----	-----	-----
Parkinson's	1.11	(0.13)	[0.86;1.39]	0.374	0.93	(0.17)	[0.65;1.33]	0.678	-----	-----	-----	-----
Renal Failure	1.07	(0.07)	[0.95;1.21]	0.292	1.35	(0.10)	[1.16;1.56]	<0.001	0.93	(0.12)	[0.72;1.2]	0.571
Diseases of blood	0.93	(0.05)	[0.85;1.06]	0.201	-----	-----	-----	-----	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	-----	-----	-----	-----	0.74	(0.1)	[0.57;0.97]	0.026
Constant	0.01	(0.04)	[0.00;7.06]	0.174	0.00	(0.00)	[0.00;0.18]	0.025	0	(0)	[0;319640.8]	0.405

Results of the subgroup analysis including only patients with dementia (costs)

	site one (n=2,321)			site two (n=1,053)			site three (n=280)		
	Follow-up period	Total costs in 6 months after discharge		Follow-up period	Total costs in 6 months after discharge		Follow-up period	Total costs in 6 months after discharge	
	coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value		coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value		coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value	
HAH (hospital)	0.76 (0.05) [0.66;0.87] 0	1.18 (0.11) [0.99;1.41] 0.071		0.76 (0.06) [0.66;0.88] 0	0.75 (0.09) [0.59;0.96] 0.021		0.87 (0.15) [0.63;1.21] 0.409	1.58 (0.41) [0.95;2.63] 0.078	
Admission date	1 (0) [1;1] 0.528	1.00 (0.00) [1.00;1.00] 0.329		1 (0) [1;1] 0.513	1.00 (0.00) [1.00;1.00] 0.532		1 (0) [1;1] 0.002	1 (0) [0.99;1] 0.003	
ICD10 primary	1 (0) [1;1] 0.025	1.00 (0.00) [1.00;1.00] 0.003		1 (0) [1;1] 0.079	1.00 (0.00) [1.00;1.00] 0.008		1 (0) [1;1] 0.666	1 (0) [1;1] 0.123	
ICD10 secondary	1 (0) [1;1] 0.027	1.00 (0.00) [1.00;1.00] 0.086		-----	-----		1 (0) [1;1] 0.946	1 (0) [1;1] 0.594	
2yrs pre AE costs	1 (0) [1;1] 0.063	1.00 (0.00) [1.00;1.00] 0.021		1 (0) [1;1] 0.979	1.00 (0.00) [1.00;1.00] 0.93		1 (0) [1;1] 0.57	1 (0) [1;1] 0.331	
2yrs pre elective costs	1 (0) [1;1] 0.913	1.00 (0.00) [1.00;1.00] 0.708		1 (0) [1;1] 0.979	1.00 (0.00) [1.00;1.00] 0.889		1 (0) [1;1] 0.115	1 (0) [1;1] 0.208	
2yrs pre non-elective costs	1 (0) [1;1] 0.564	1.00 (0.00) [1.00;1.00] 0.605		1 (0) [1;1] 0.031	1.00 (0.00) [1.00;1.00] 0.008		1 (0) [1;1] 0.888	1 (0) [1;1] 0.639	
2yrs pre day case costs	1 (0) [1;1] 0.455	1.00 (0.00) [1.00;1.00] 0.632		1 (0) [1;1] 0.725	1.00 (0.00) [1.00;1.00] 0.307		1 (0) [1;1] 0.1	1 (0) [1;1] 0.279	
2yrs pre geriatric ward costs	1 (0) [1;1] 0.233	1.00 (0.00) [1.00;1.00] 0.566		1 (0) [1;1] 0.012	1.00 (0.00) [1.00;1.00] 0.003		1 (0) [1;1] 0.907	1 (0) [1;1] 0.952	
2yrs pre mental ward costs	1 (0) [1;1] 0.343	1.00 (0.00) [1.00;1.00] 0.335		1 (0) [1;1] 0.084	1.00 (0.00) [1.00;1.00] 0.042		1 (0) [1;1] 0.01	1 (0) [1;1] 0.021	
2yrs pre outpatient costs	1 (0) [1;1] 0.066	1.00 (0.00) [1.00;1.00] 0.082		1 (0) [1;1] 0.001	1.00 (0.00) [1.00;1.00] 0.001		1 (0) [1;1] 0.685	1 (0) [1;1] 0.403	
2yrs pre medication costs	1 (0) [1;1] 0.306	1.00 (0.00) [1.00;1.00] 0.316		1 (0) [1;1] 0.13	1.00 (0.00) [1.00;1.00] 0.265		1 (0) [1;1] 0.042	1 (0) [1;1] 0.044	
Died within 6months	0.81 (0.06) [0.7;0.94] 0.005	0.70 (0.07) [0.58;0.85] <0.001		0.89 (0.07) [0.76;1.03] 0.118	0.73 (0.09) [0.58;0.93] 0.011		0.66 (0.13) [0.45;0.96] 0.031	0.44 (0.13) [0.25;0.77] 0.004	
Number of LTCs	1.06 (0.03) [1;1.12] 0.069	1.07 (0.04) [1.00;1.16] 0.063		1.08 (0.03) [1.02;1.14] 0.006	1.15 (0.05) [1.05;1.26] 0.003		1.04 (0.06) [0.94;1.16] 0.443	1.01 (0.08) [0.86;1.18] 0.935	
Age on admission	0.99 (0.01) [0.98;1] 0.094	0.98 (0.01) [0.97;1.00] 0.015		0.98 (0.01) [0.97;1] 0.007	0.97 (0.01) [0.95;0.99] 0.003		1 (0.01) [0.98;1.03] 0.933	1 (0.02) [0.97;1.03] 0.946	
Male	1.13 (0.08) [0.99;1.31] 0.076	1.14 (0.11) [0.95;1.37] 0.151		0.95 (0.07) [0.82;1.11] 0.511	0.95 (0.12) [0.74;1.22] 0.679		1.05 (0.17) [0.76;1.43] 0.78	1.07 (0.26) [0.67;1.71] 0.774	
SES	1.01 (0.01) [0.98;1.04] 0.693	1.01 (0.02) [0.97;1.04] 0.77		1.03 (0.01) [1;1.05] 0.053	1.06 (0.02) [1.01;1.10] 0.010		1.03 (0.03) [0.97;1.09] 0.3	1.04 (0.04) [0.96;1.12] 0.3	
Atrial Fibrillation	-----	-----		1.03 (0.09) [0.87;1.23] 0.722	1.00 (0.14) [0.77;1.31] 0.986		-----	-----	
Arthritis	1.02 (0.09) [0.86;1.2] 0.833	1.02 (0.11) [0.83;1.25] 0.862		-----	-----		-----	-----	
Cancer	-----	-----		1.04 (0.1) [0.87;1.24] 0.679	1.06 (0.16) [0.79;1.43] 0.688		-----	-----	
CVD	0.92 (0.07) [0.78;1.08] 0.3	0.91 (0.1) [0.74;1.12] 0.374		0.98 (0.08) [0.83;1.16] 0.845	0.95 (0.14) [0.72;1.26] 0.741		1.39 (0.28) [0.94;2.06] 0.103	1.65 (0.48) [0.93;2.91] 0.085	
Liver disease	0.8 (0.12) [0.59;1.08] 0.138	0.8 (0.16) [0.54;1.20] 0.286		-----	-----		-----	-----	
CHD	1.01 (0.09) [0.85;1.2] 0.917	1.05 (0.12) [0.84;1.30] 0.688		0.94 (0.09) [0.78;1.12] 0.482	0.98 (0.14) [0.74;1.30] 0.891		-----	-----	
Epilepsy	-----	-----		0.97 (0.15) [0.72;1.3] 0.842	0.78 (0.16) [0.53;1.16] 0.221		-----	-----	
Heart Failure	1.03 (0.11) [0.83;1.27] 0.818	1.02 (0.14) [0.79;1.33] 0.878		0.92 (0.11) [0.73;1.15] 0.452	0.90 (0.17) [0.62;1.29] 0.558		0.83 (0.19) [0.53;1.3] 0.409	1.16 (0.42) [0.57;2.37] 0.687	
Multiple sclerosis	-----	-----		0.4 (0.06) [0.29;0.54] 0	0.18 (0.07) [0.09;0.37] <0.001		-----	-----	
Parkinson's	1.13 (0.15) [0.88;1.46] 0.333	1.00 (0.17) [0.72;1.39] 0.992		0.87 (0.14) [0.63;1.18] 0.365	0.68 (0.20) [0.39;1.20] 0.188		-----	-----	
Renal Failure	1.03 (0.1) [0.85;1.24] 0.769	1.12 (0.14) [0.88;1.42] 0.354		0.9 (0.09) [0.75;1.09] 0.296	0.82 (0.13) [0.60;1.12] 0.203		1.2 (0.24) [0.81;1.78] 0.354	1.25 (0.35) [0.72;2.17] 0.435	
Diseases of blood	0.93 (0.08) [0.79;1.11] 0.437	0.90 (0.1) [0.73;1.11] 0.337		-----	-----		-----	-----	
Diabetes	-----	-----		-----	-----		0.85 (0.18) [0.55;1.3] 0.449	0.92 (0.26) [0.52;1.6] 0.756	
Constant	469.5 (2319.98) [0.03;7547051] 0.213	22.71 (140.52) [0;4194325] 0.614		2796754 (19900000) [2.38;3290000000000] 0.037	40500000 (472000000) [0;32900000000000000] 0.132		2.82E+29 (5.36E+30) [18000000000000;4.43E+45] 0	3.34E+38 (9.1E+39) [2100000000000000;5.29E+61] 0.001	

## Results of the subgroup analysis including only patients with dementia (mortality risk)

	site one (n=2,321)	site two (n=1,053)	site three (n=280)
	Mortality rate during follow-up coefficient (se) [95%CI] p value	Mortality rate during follow-up coefficient (se) [95%CI] p value	Mortality rate during follow-up coefficient (se) [95%CI] p value
HAH (hospital)	1.05 (0.09) [0.89;1.24] 0.594	1.41 (0.12) [1.19;1.67] <0.001	1.65 (0.32) [1.12;2.41] 0.011
Admission date	1.00 (0.00) [1.00;1.00] 0.19	1.00 (0.00) [1.00;1.00] 0.001	1 (0) [1;1] 0.788
ICD10 primary	1.00 (0.00) [1.00;1.00] <0.001	1.00 (0.00) [1.00;1.00] 0.001	1 (0) [1;1] 0.14
ICD10 secondary	1.00 (0.00) [1.00;1.00] 0.207	-----	1 (0) [1;1] 0.979
2yrs pre AE costs	1.00 (0.00) [1.00;1.00] 0.251	1.00 (0.00) [1.00;1.00] 0.609	1 (0) [1;1] 0.029
2yrs pre elective costs	1.00 (0.00) [1.00;1.00] 0.735	1.00 (0.00) [1.00;1.00] 0.129	1 (0) [1;1] 0.554
2yrs pre non-elective costs	1.00 (0.00) [1.00;1.00] 0.173	1.00 (0.00) [1.00;1.00] 0.484	1 (0) [1;1] 0.814
2yrs pre day case costs	1.00 (0.00) [1.00;1.00] 0.088	1.00 (0.00) [1.00;1.00] 0.004	1 (0) [1;1] 0.896
2yrs pre geriatric ward costs	1.00 (0.00) [1.00;1.00] 0.644	1.00 (0.00) [1.00;1.00] <0.001	1 (0) [1;1] 0.783
2yrs pre mental ward costs	1.00 (0.00) [1.00;1.00] 0.569	1.00 (0.00) [1.00;1.00] 0.112	1 (0) [1;1] 0
2yrs pre outpatient costs	1.00 (0.00) [1.00;1.00] 0.070	1.00 (0.00) [1.00;1.00] 0.167	1 (0) [1;1] 0
2yrs pre medication costs	1.00 (0.00) [1.00;1.00] 0.004	1.00 (0.00) [1.00;1.00] 0.156	1 (0) [1;1] 0.011
Died within 6months	-----	-----	-----
Number of LTCs	0.94 (0.03) [0.88;1.01] 0.113	0.95 (0.03) [0.89;1.01] 0.115	0.98 (0.07) [0.86;1.13] 0.827
Age on admission	1.04 (0.01) [1.02;1.05] <0.001	1.03 (0.01) [1.01;1.04] <0.001	1.04 (0.02) [1.07;1.07] 0.024
Male	1.19 (0.11) [0.99;1.42] 0.063	1.17 (0.10) [0.99;1.38] 0.070	1.18 (0.25) [0.78;1.79] 0.43
SES	0.97 (0.02) [0.94;1.01] 0.134	1.00 (0.02) [0.97;1.03] 0.991	0.96 (0.04) [0.88;1.04] 0.3
Atrial Fibrillation	-----	1.03 (0.11) [0.85;1.26] 0.75	-----
Arthritis	1.06 (0.11) [0.86;1.30] 0.600	-----	-----
Cancer	-----	1.40 (0.13) [1.16;1.68] <0.001	-----
CVD	1.55 (0.41) [0.92;2.61] 0.099	1.14 (0.11) [0.94;1.39] 0.176	1.02 (0.25) [0.63;1.65] 0.925
Liver disease	0.98 (0.11) [0.79;1.21] 0.845	-----	-----
CHD	1.21 (0.16) [0.94;1.56] 0.135	0.99 (0.10) [0.81;1.20] 0.885	-----
Epilepsy	-----	1.26 (0.19) [0.94;1.70] 0.120	-----
Heart Failure	1.21 (0.16) [0.94;1.56] 0.135	1.33 (0.17) [1.04;1.70] 0.023	1.88 (0.49) [1.12;3.14] 0.017
Multiple sclerosis	-----	0.96 (0.51) [0.34;2.72] 0.932	-----
Parkinson's	1.26 (0.22) [0.9;1.78] 0.180	1.04 (0.20) [0.71;1.51] 0.848	-----
Renal Failure	1.06 (0.12) [0.84;1.32] 0.637	1.15 (0.12) [0.93;1.41] 0.192	0.56 (0.16) [0.32;0.97] 0.037
Diseases of blood	0.96 (0.11) [0.77;1.19] 0.709	-----	-----
Diabetes	-----	-----	0.6 (0.2) [0.32;1.15] 0.123
Constant	0.00 (0.00) [0.00;1.37] 0.057	0.00 (0.00) [0.00;0.00] <0.001	0 (0) [0;18100000000000000] 0.652

Results of the subgroup analysis excluding those who had died

	site one (n=10,132)				site two (n=3,584)				site three (n=1691)			
	Follow-up period		Total costs in 6 months after discharge		Follow-up period		Total costs in 6 months after discharge		Follow-up period		Total costs in 6 months after discharge	
	coefficient (se) [95%CI]	p value	coefficient (se) [95%CI]	p value	coefficient (se) [95%CI]	p value	coefficient (se) [95%CI]	p value	coefficient (se) [95%CI]	p value	coefficient (se) [95%CI]	p value
HAH (hospital)	0.85 (0.04) [0.77;0.94]	0.002	1.23 (0.08) [1.08;1.4]	0.002	1.11 (0.06) [1.1;1.25]	0.058	1.17 (0.10) [0.99;1.38]	0.070	1.20 (0.11) [1.1;1.43]	0.046	1.71 (0.20) [1.36;2.15]	<0.001
Admission date	1 (0) [1;1]	0.076	1.00 (0.00) [1.00;1.00]	0.032	1 (0) [1;1]	0.833	1.00 (0.00) [1.00;1.00]	0.337	1 (0) [1;1]	0.075	1 (0) [1;1]	0.282
ICD10 primary	1 (0) [1;1]	0.692	1.00 (0.00) [1.00;1.00]	0.993	1 (0) [1;1]	0.126	1.00 (0.00) [1.00;1.00]	0.038	1 (0) [1;1]	0.282	1 (0) [1;1]	0.279
ICD10 secondary	1 (0) [1;1]	0.817	1.00 (0.00) [1.00;1.00]	0.473	1 (0) [1;1]	0.014	1.00 (0.00) [1.00;1.00]	0.024	1 (0) [1;1]	0.724	1 (0) [1;1]	0.801
2yrs pre AE costs	1 (0) [1;1]	0.08	1.00 (0.00) [1.00;1.00]	0.012	1 (0) [1;1]	0.461	1.00 (0.00) [1.00;1.00]	0.135	1 (0) [1;1]	0.435	1 (0) [1;1]	0.761
2yrs pre elective costs	1 (0) [1;1]	0.015	1.00 (0.00) [1.00;1.00]	0.046	1 (0) [1;1]	0.576	1.00 (0.00) [1.00;1.00]	0.429	1 (0) [1;1]	0.63	1 (0) [1;1]	0.725
2yrs pre non-elective costs	1 (0) [1;1]	0	1.00 (0.00) [1.00;1.00]	<0.001	1 (0) [1;1]	0.651	1.00 (0.00) [1.00;1.00]	0.700	1 (0) [1;1]	0.199	1 (0) [1;1]	0.01
2yrs pre day case costs	1 (0) [1;1]	0.416	1.00 (0.00) [1.00;1.00]	0.158	1 (0) [1;1]	0.057	1.00 (0.00) [1.00;1.00]	0.023	1 (0) [1;1]	0.068	1 (0) [1;1]	0.064
2yrs pre geriatric ward costs	1 (0) [1;1]	0.031	1.00 (0.00) [1.00;1.00]	0.029	1 (0) [1;1]	0.625	1.00 (0.00) [1.00;1.00]	0.806	1 (0) [1;1]	0.484	1 (0) [1;1]	0.103
2yrs pre mental ward costs	1 (0) [1;1]	0.206	1.00 (0.00) [1.00;1.00]	0.166	1 (0) [1;1]	0.009	1.00 (0.00) [1.00;1.00]	0.020	1 (0) [1;1]	0.01	1 (0) [1;1]	0.004
2yrs pre outpatient costs	1 (0) [1;1]	0.236	1.00 (0.00) [1.00;1.00]	0.187	1 (0) [1;1]	0.748	1.00 (0.00) [1.00;1.00]	0.802	1 (0) [1;1]	0.798	1 (0) [1;1]	0.908
2yrs pre medication costs	1 (0) [1;1]	0.399	1.00 (0.00) [1.00;1.00]	0.383	1 (0) [1;1]	0.011	1.00 (0.00) [1.00;1.00]	0.016	1 (0) [1;1]	0.37	1 (0) [1;1]	0.77
Number of LTCs	1.08 (0.02) [1.04;1.12]	0	1.12 (0.03) [1.07;1.18]	<0.001	1.03 (0.02) [0.99;1.08]	0.169	1.06 (0.04) [0.99;1.13]	0.076	1.06 (0.03) [1.01;1.13]	0.032	1.09 (0.04) [1.01;1.17]	0.026
Age on admission	1.01 (0) [1;1.01]	0.025	1.01 (0.00) [1.00;1.02]	0.048	1.01 (0) [1;1.01]	0.054	1.01 (0.01) [1.00;1.02]	0.254	1.02 (0.01) [1.01;1.03]	0.019	1.01 (0.01) [0.99;1.03]	0.171
Male	1.11 (0.06) [1.1;1.22]	0.051	1.12 (0.07) [0.99;1.26]	0.085	0.94 (0.06) [0.83;1.07]	0.353	0.97 (0.09) [0.80;1.17]	0.752	0.97 (0.09) [0.8;1.16]	0.716	1 (0.12) [0.79;1.26]	0.974
SES	1 (0.01) [0.98;1.02]	0.965	1 (0.01) [0.98;1.03]	0.778	1.02 (0.01) [1;1.04]	0.081	1.03 (0.01) [1.00;1.06]	0.023	1 (0.02) [0.96;1.03]	0.822	1 (0.02) [0.95;1.05]	0.951
Atrial Fibrillation	-----	-----	-----	-----	1.07 (0.07) [0.94;1.21]	0.305	1.09 (0.10) [0.92;1.29]	0.335	-----	-----	-----	-----
Arthritis	0.99 (0.05) [0.89;1.1]	0.889	0.96 (0.06) [0.85;1.1]	0.584	-----	-----	-----	-----	-----	-----	-----	-----
Cancer	-----	-----	-----	-----	1 (0.07) [0.88;1.15]	0.961	1.01 (0.10) [0.84;1.23]	0.899	-----	-----	-----	-----
CVD	1.04 (0.07) [0.91;1.2]	0.552	1.00 (0.09) [0.85;1.19]	0.956	1.14 (0.08) [1;1.3]	0.058	1.14 (0.11) [0.95;1.36]	0.174	1.12 (0.14) [0.88;1.43]	0.367	1.1 (0.17) [0.81;1.5]	0.531
Liver disease	1.35 (0.2) [1.01;1.8]	0.045	1.31 (0.21) [0.95;1.81]	0.097	-----	-----	-----	-----	-----	-----	-----	-----
Dementia	1.16 (0.07) [1.04;1.3]	0.009	1.17 (0.08) [1.01;1.35]	0.033	1.08 (0.07) [0.96;1.22]	0.195	1.11 (0.10) [0.93;1.31]	0.244	1.37 (0.16) [1.09;1.73]	0.008	1.49 (0.23) [1.09;2.02]	0.011
CHD	0.82 (0.06) [0.72;0.94]	0.004	0.79 (0.07) [0.67;0.93]	0.004	1.01 (0.07) [0.87;1.16]	0.941	1.03 (0.10) [0.85;1.24]	0.799	-----	-----	-----	-----
Epilepsy	-----	-----	-----	-----	1.08 (0.12) [0.86;1.35]	0.518	1.09 (0.17) [0.80;1.48]	0.581	-----	-----	-----	-----
Heart Failure	1.1 (0.07) [0.97;1.25]	0.131	1.08 (0.08) [0.93;1.26]	0.293	1.08 (0.08) [0.94;1.24]	0.287	1.07 (0.11) [0.88;1.31]	0.491	1.05 (0.13) [0.82;1.34]	0.719	1.01 (0.16) [0.74;1.39]	0.932
Multiple sclerosis	-----	-----	-----	-----	0.72 (0.14) [0.49;1.06]	0.095	0.66 (0.21) [0.35;1.25]	0.202	-----	-----	-----	-----
Parkinson's	1.19 (0.1) [1;1.41]	0.05	1.15 (0.13) [0.93;1.43]	0.19	1.22 (0.18) [0.91;1.64]	0.193	1.34 (0.27) [0.91;1.98]	0.139	-----	-----	-----	-----
Renal Failure	1.01 (0.06) [0.89;1.14]	0.911	1.00 (0.07) [0.87;1.16]	0.949	1.06 (0.08) [0.92;1.22]	0.443	1.06 (0.11) [0.86;1.29]	0.602	1.12 (0.15) [0.86;1.46]	0.411	1.19 (0.2) [0.85;1.66]	0.317
Diseases of blood	1.04 (0.06) [0.94;1.16]	0.414	1.04 (0.07) [0.92;1.19]	0.516	-----	-----	-----	-----	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	-----	-----	-----	-----	1.33 (0.15) [1.07;1.65]	0.01	1.37 (0.19) [1.04;1.81]	0.026
Constant	3.67 (13.85) [0.5959]	0.73	0.07 (0.31) [0.592.13]	0.558	1064.79 (5943.4) [0.02;60000000]	0.212	0.89 (6.96) [0.4301665]	0.988	101000000000 (105000000000) [149.57;68100000000000000000]	0.015	1320000000 (18000000000) [0.567E+20]	0.124

Results of the sensitivity analysis

	site one (n=13,267)		site two (n=4,769)		site three (n=2110)	
	Total costs in follow-up (50% higher HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% lower HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% higher HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% lower HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% higher HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% lower HAH unit costs) coefficient (se) [95%CI] p value
HAH (hospital)	0.87 (0.03) [0.81;0.94] 0.001	0.77 (0.03) [0.71;0.84] 0	1.18 (0.05) [1.09;1.28] 0	0.81 (0.04) [0.74;0.9] 0	1.23 (0.09) [1.07;1.42] 0.004	1.07 (0.09) [0.91;1.25] 0.399
Admission date	1 (0) [1;1] 0.071	1 (0) [1;1] 0.048	1 (0) [1;1] 0.489	1 (0) [1;1] 0.3	1 (0) [1;1] 0.007	1 (0) [1;1] 0.012
ICD10 primary	1 (0) [1;1] 0.649	1 (0) [1;1] 0.671	1 (0) [1;1] 0.001	1 (0) [1;1] 0.001	1 (0) [1;1] 0.167	1 (0) [1;1] 0.16
ICD10 secondary	1 (0) [1;1] 0.588	1 (0) [1;1] 0.701	1 (0) [1;1] 0.148	1 (0) [1;1] 0.145	1 (0) [1;1] 0.875	1 (0) [1;1] 0.909
2yrs pre AE costs	1 (0) [1;1] 0.223	1 (0) [1;1] 0.261	1 (0) [1;1] 0.687	1 (0) [1;1] 0.561	1 (0) [1;1] 0.307	1 (0) [1;1] 0.267
2yrs pre elective costs	1 (0) [1;1] 0.909	1 (0) [1;1] 0.904	1 (0) [1;1] 0.537	1 (0) [1;1] 0.657	1 (0) [1;1] 0.896	1 (0) [1;1] 0.813
2yrs pre non-elective costs	1 (0) [1;1] 0	1 (0) [1;1] 0	1 (0) [1;1] 0.919	1 (0) [1;1] 0.458	1 (0) [1;1] 0.015	1 (0) [1;1] 0.021
2yrs pre day case costs	1 (0) [1;1] 0.099	1 (0) [1;1] 0.097	1 (0) [1;1] 0.006	1 (0) [1;1] 0.004	1 (0) [1;1] 0.131	1 (0) [1;1] 0.148
2yrs pre geriatric ward costs	1 (0) [1;1] 0.006	1 (0) [1;1] 0.005	1 (0) [1;1] 0.002	1 (0) [1;1] 0	1 (0) [1;1] 0.562	1 (0) [1;1] 0.713
2yrs pre mental ward costs	1 (0) [1;1] 0.905	1 (0) [1;1] 0.854	1 (0) [1;1] 0.005	1 (0) [1;1] 0.02	1 (0) [1;1] 0.09	1 (0) [1;1] 0.132
2yrs pre outpatient costs	1 (0) [1;1] 0.086	1 (0) [1;1] 0.088	1 (0) [1;1] 0.027	1 (0) [1;1] 0.026	1 (0) [1;1] 0.699	1 (0) [1;1] 0.675
2yrs pre medication costs	1 (0) [1;1] 0.713	1 (0) [1;1] 0.892	1 (0) [1;1] 0.136	1 (0) [1;1] 0.236	1 (0) [1;1] 0.713	1 (0) [1;1] 0.663
Died within 6months	1.03 (0.04) [0.95;1.11] 0.492	1.02 (0.04) [0.94;1.12] 0.572	1.05 (0.04) [0.97;1.14] 0.252	1.05 (0.05) [0.95;1.16] 0.38	1.06 (0.08) [0.91;1.23] 0.474	1.06 (0.09) [0.89;1.25] 0.517
Number of LTCs	1.08 (0.02) [1.05;1.11] 0	1.09 (0.02) [1.05;1.13] 0	1.04 (0.02) [1;1.07] 0.033	1.04 (0.02) [0.99;1.08] 0.093	1.06 (0.02) [1.01;1.1] 0.016	1.06 (0.03) [1.01;1.11] 0.019
Age on admission	1 (0) [1;1.01] 0.323	1 (0) [1;1.01] 0.452	1 (0) [1;1.01] 0.788	1 (0) [0.99;1.01] 0.789	1.01 (0.01) [1;1.02] 0.037	1.01 (0.01) [1;1.02] 0.055
Male	1.09 (0.04) [1.01;1.18] 0.035	1.1 (0.05) [1.01;1.2] 0.034	0.96 (0.04) [0.88;1.04] 0.311	0.95 (0.06) [0.85;1.07] 0.382	0.97 (0.07) [0.84;1.12] 0.686	0.97 (0.08) [0.82;1.14] 0.704
SES	1 (0.01) [0.98;1.02] 0.979	1 (0.01) [0.98;1.02] 0.954	1.01 (0.01) [1;1.02] 0.17	1.01 (0.01) [0.99;1.03] 0.205	1 (0.01) [0.97;1.03] 0.887	1 (0.02) [0.97;1.03] 0.917
Atrial Fibrillation	-----	-----	1.08 (0.05) [0.98;1.18] 0.104	1.1 (0.06) [0.98;1.23] 0.094	-----	-----
Arthritis	0.96 (0.04) [0.89;1.05] 0.392	0.96 (0.05) [0.88;1.05] 0.403	-----	-----	-----	-----
Cancer	-----	-----	1.04 (0.05) [0.95;1.14] 0.426	1.03 (0.06) [0.92;1.16] 0.566	-----	-----
CVD	1.02 (0.05) [0.92;1.13] 0.743	1.02 (0.06) [0.91;1.14] 0.794	1.07 (0.05) [0.98;1.18] 0.146	1.08 (0.07) [0.96;1.22] 0.199	1.09 (0.11) [0.91;1.32] 0.352	1.11 (0.12) [0.9;1.37] 0.324
Liver disease	1.21 (0.13) [0.98;1.48] 0.073	1.23 (0.14) [0.98;1.53] 0.074	-----	-----	-----	-----
Dementia	1.07 (0.05) [0.97;1.17] 0.16	1.07 (0.05) [0.97;1.18] 0.2	1.02 (0.05) [0.93;1.11] 0.738	0.99 (0.06) [0.88;1.1] 0.795	1.14 (0.11) [0.95;1.37] 0.153	1.14 (0.12) [0.94;1.4] 0.18
CHD	0.86 (0.05) [0.77;0.95] 0.004	0.85 (0.05) [0.76;0.95] 0.005	1.07 (0.05) [0.97;1.18] 0.174	1.02 (0.06) [0.9;1.15] 0.785	-----	-----
Epilepsy	-----	-----	1.04 (0.1) [0.86;1.26] 0.664	1.02 (0.12) [0.82;1.28] 0.841	-----	-----
Heart Failure	1.09 (0.05) [0.99;1.2] 0.095	1.09 (0.06) [0.98;1.21] 0.11	1.07 (0.06) [0.96;1.19] 0.201	1.09 (0.07) [0.96;1.24] 0.177	1.01 (0.1) [0.83;1.22] 0.947	1.02 (0.11) [0.82;1.25] 0.885
Multiple sclerosis	-----	-----	0.76 (0.1) [0.59;0.98] 0.033	0.73 (0.11) [0.54;0.99] 0.046	-----	-----
Parkinson's	1.23 (0.11) [1.04;1.45] 0.018	1.24 (0.12) [1.03;1.49] 0.021	1.07 (0.14) [0.84;1.37] 0.582	1.11 (0.18) [0.81;1.52] 0.512	-----	-----
Renal Failure	1.04 (0.05) [0.95;1.13] 0.436	1.03 (0.05) [0.93;1.13] 0.601	1.04 (0.05) [0.94;1.15] 0.408	1.06 (0.07) [0.94;1.2] 0.366	1.11 (0.11) [0.91;1.36] 0.3	1.12 (0.13) [0.9;1.39] 0.317
Diseases of blood	1.05 (0.05) [0.97;1.14] 0.246	1.05 (0.05) [0.96;1.15] 0.308	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	1.2 (0.11) [1;1.42] 0.044	1.22 (0.12) [1.01;1.48] 0.042
Constant	26.62 (74.48) [0.11;6410.63] 0.241	8.84 (27.52) [0.02;3945.99] 0.484	295178.8 (1199605) [102.52;850000000] 0.002	1223534 (6192074) [60.23;24900000000] 0.006	1480000000000 (12700000000000) [776224.7;2.84E+20] 0	3100000000(292000000) [292677.5;3.28E+21] 0.001

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47

For peer review only



Appendix 4 STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	
		<i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	
Variables	7	(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed	6-8
		<i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Data sources/ measurement	8*	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Bias	9	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Study size	10	Describe any efforts to address potential sources of bias	6-8
Quantitative variables	11	Explain how the study size was arrived at	6-8
Statistical methods	12	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
		(a) Describe all statistical methods, including those used to control for confounding	8
		(b) Describe any methods used to examine subgroups and interactions	8
		(c) Explain how missing data were addressed	8
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	6-8
		(e) Describe any sensitivity analyses	8

Continued on next page

<b>Results</b>		<b>Page</b>	
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9-10
		(b) Give reasons for non-participation at each stage	9-10
		(c) Consider use of a flow diagram	10
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9,12
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	6, 13
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	13
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13, 15
		(b) Report category boundaries when continuous variables were categorized	NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	15
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	17-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19-20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Should I stay or should I go? A retrospective propensity score matched analysis using administrative data of hospital-at-home for older people

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-023350.R1
Article Type:	Research
Date Submitted by the Author:	18-Dec-2018
Complete List of Authors:	Tsiachristas, Apostolos; University of Oxford, Health Economics Research Centre, Nuffield Department of Population Health Ellis, Graham; Monklands Hospital, NHS Lanarkshire Buchanan, Scott; Information Services Division, National Services Scotland Langhorne, Peter; University of Glasgow, Institute of Cardiovascular and Medical Sciences Stott, David; Institute of Cardiovascular and Medical Sciences, University of Glasgow, Geriatric Medicine Shepperd, S; University of Oxford, Nuffield Department of Population Health
<b>Primary Subject Heading</b>:	Geriatric medicine
Secondary Subject Heading:	Health economics, Health services research
Keywords:	hospital-at-home, admission avoidance, intermediate care, costs, mortality, UK

SCHOLARONE™  
Manuscripts

# Should I stay or should I go? A retrospective propensity score matched analysis using administrative data of hospital-at-home for older people

Apostolos Tsiachristas<sup>1</sup>, Graham Ellis<sup>2</sup>, Scott Buchanan<sup>3</sup>, Peter Langhorne<sup>4</sup>, David J Stott<sup>4</sup>, Sasha Shepperd<sup>1</sup>.

<sup>1</sup> Nuffield Department of Population Health, University of Oxford, Oxford, UK

<sup>2</sup> Monklands Hospital, NHS Lanarkshire, Glasgow, UK

<sup>3</sup> Information Services Division, National Services Scotland, Edinburgh, UK

<sup>4</sup> Institute of Cardiovascular and Medical Sciences, University of Glasgow, Glasgow, UK

Word Count: 4783

Correspondence to: Apostolos Tsiachristas, Health Economics Research Centre, Nuffield Department of Population Health, Richard Doll building, Old Road Campus, OX3 7LF, Oxford, UK; Tel: +44(0)1865 289470; email: [apostolos.tsiachristas@dph.ox.ac.uk](mailto:apostolos.tsiachristas@dph.ox.ac.uk)

## Abstract

**Objectives:** To compare the characteristics of populations admitted to hospital-at-home services with the population admitted to hospital and assess the association of these services with healthcare costs and mortality.

**Design:** In a retrospective observational cohort study of linked patient level data, we used propensity score matching in combination with regression analysis.

**Participants:** Patients aged 65 years and older admitted to hospital-at-home or hospital.

**Interventions:** Three geriatrician-led admission avoidance hospital-at-home services in Scotland.

**Outcome measures:** Healthcare costs and mortality.

**Results:** Patients in hospital-at-home were older and more socioeconomically disadvantaged, had higher rates of previous hospitalization, and there was a greater proportion of women and people with several chronic conditions compared with the population admitted to hospital. The cost of providing hospital-at-home varied between the three sites from £628 to £2928 per admission. Hospital-at-home was associated with 18% lower costs during the follow-up period in site one (ratio of means 0.82; 95%CI: 0.76-0.89). Limiting the analysis to costs during the 6 months following index discharge, patients in the hospital-at-home cohorts had 27% higher costs (ratio of means 1.27; 95%CI: 1.14-1.41) in site one, 9% (ratio of means 1.09; 95%CI: 0.95-1.24) in site two and 70% in site three (ratio of means 1.70; 95%CI: 1.40-2.07) compared with patients in the control cohorts. Admission to hospital-at-home was associated with an increased risk of death during the follow-up period in all three sites (1.09, 95%CI: 1.00-1.19 site one; 1.29, 95%CI: 1.15-1.44 site two; 1.27, 95%CI: 1.06-1.54 site three).

**Conclusions:** Our findings indicate that in these three cohorts, the populations admitted to hospital-at-home and hospital differ. We cannot rule out the risk of residual confounding, as our analysis relied on an administrative data set and we lacked data on disease severity and type of hospitalised care received in the control cohorts.

### Strengths and limitations of the study

- The study used a large dataset from three of the largest Health Boards in Scotland.
- The retrospective cohort study has allowed inferences from real world evidence.
- Various sensitivity analyses helped to address uncertainty in the results.
- The major limitation of this type of non-randomised comparison is residual confounding.
- The lack of data on quality of life, as well as use of subsequent health, social, community and informal care is a limitation.

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For peer review only

## Introduction

Organising health systems to optimise the health outcomes of older people and contain costs is a priority as populations around the world age, and the demand for healthcare continues to rise. Despite a global policy emphasis on 'care closer to home'<sup>1</sup> and initiatives that seek to ease demand for hospital based healthcare, efforts to innovate and deliver healthcare services that provide an alternative to hospital admission for older people have been piecemeal and often lack a health system perspective. A lack of evidence to support decision-making has contributed to this. Avoiding admission to hospital by providing acute healthcare in people's homes, often as a hospital outreach service, is one of the more popular service innovations and yet there is uncertainty around the effectiveness and cost-effectiveness of this form of care.<sup>2</sup>

### Box 1 Description of each service

#### Hospital-at-home

The three hospital-at-home services are broadly similar, capacity ranged between 24 to 60 beds for the period of the analysis. Each is a geriatrician-led service that is supported by nurses (sometimes nurse practitioners) and therapy practitioners for the initial assessment; geriatricians and the multi-disciplinary team review patients in their homes and meet daily (a virtual ward round) to discuss patient cases and agree actions. Rehabilitation is available within the existing team with onward referral to community rehabilitation as required, and in one site rehabilitation is accessed through a parallel community rehabilitation services. Out of hours emergency cover is provided by primary care out-of-hours. Patients are referred to the service from GPs, sometimes through a central referral number or via step down from the acute hospital. The service offers access to diagnostics such as radiology, and intravenous fluids, antibiotics and oxygen. Cases are discussed daily with the multidisciplinary team at the virtual ward round and daily management plans agreed. In one site there is close working with the day hospital where patients can be referred for follow up or for investigations. Patients access investigations and treatment with the same speed as inpatients. The services support intravenous therapies in the home.

#### Hospital

The provision of hospital based acute health services varied among the sites; in one site there were three district general hospitals (1,653 beds) that provide acute health services to a mainly urban population of 652,230, with a total of 1,653 beds; in site two a hospital (550 beds) provides acute healthcare to a population of 180,130; and in site three there are two district general hospitals (825 beds) that provide healthcare to a population of 358,900, and acute admissions are via one of the hospitals.

The use of administrative data to evaluate service delivery interventions has the potential to provide a simple and efficient mechanism to provide real-world evidence about policy relevant service innovations, and embed evaluation into local decision-making. However, previous experience of using routine data in this area of research has been of mixed success due to a limited set of variables, missing data and the complexity of policy relevant questions that often require a broad and longer term perspective.<sup>3</sup> Administrative healthcare data collected in Scotland is unique in that it is population based, with little missing data. The aim of this study was to use these data to compare the characteristics of populations from three Health Boards who used a geriatrician-led hospital-at-home service with the population who received hospital care, and to assess the impact of these services on healthcare costs and mortality.

## Methods

### *Setting*

We used patient level data collected by three of the fourteen Scottish Health Boards of all patients aged 64 years and older, and who were admitted (referred to as the index admission) to either geriatrician-led admission avoidance hospital-at-home or inpatient hospital between August 2014 and December 2015 (17 months) in site one and site two, and between January 2015 and December 2016 (24 months) in site three. These services are commissioned by integrated health and social care boards that cover a population of almost 1.5 million in urban and rural areas. The Information Service Division (ISD), part of NHS Scotland, de-identified, cleaned and linked individual patient records to derive activity and costs related to periods before and after the index admissions. We obtained signed release forms from each Board's Caldicott guardian, and followed the ISD data sharing agreement.

### *Intervention*

The three service models of hospital-at-home provided an admission avoidance function that provided an alternative to inpatient hospital care, and had similar structures and functions; the main differences were in the capacity of the services and the organisation of services for rehabilitation. (Box 1)

### *Data sources*

Data were available for each person for two years prior to their index admission, and from the point of their index admission to six months after index discharge from hospital-at-home or hospital. Box 2 presents a full list of all variables included in the dataset. Figure 1 provides schematic examples of the differing calendar time periods studied before and after index admission for people admitted between August 2014 and December 2015 to hospital-at-home (Patients A and B) or hospital (Patients C and D) in site one. As this illustrates, the maximum follow-up period for each patient consisted of the period between index admission and index discharge and 6 months after index discharge. The data were collected via the data systems used in hospitals to collect patient data. Hospital-at-home activity data was submitted to ISD from the local systems of the three sites. The linked data set included acute inpatient, geriatric long stay and day case, mental health admissions, outpatient appointments accident and emergency attendances, community prescribing and death registrations.



Figure 1. Illustration of obtained data from site one

**Box 2. List of variables included in the dataset**

Costs of accidents and emergency attendances,  
 Costs of acute day cases,  
 Costs of acute elective hospitalisation,  
 Costs of acute non-elective hospitalisation,  
 Costs of geriatric wards,  
 Costs of mental health wards,  
 Costs of outpatient visits,  
 Costs of prescribed medication,  
 Costs of (re)admission to hospital-at-home.  
 Primary ICD-10 codes on index discharge,  
 Secondary ICD-10 codes on index discharge,  
 Length of stay of the index admission,  
 Age on index admission,  
 Gender,  
 Scottish Index of Multiple Deprivation (SIMD), 1 (most deprived) to 10 (most affluent)  
 Long-term conditions,  
 Date of death (if applicable),  
 Based on ICD-10 codes:  
 Cardiovascular disease (CVD) (I60-I69, G45)  
 Chronic obstructive pulmonary disorder (COPD) (J41-J44, J47),  
 Dementia (F00-F03, F05.1),  
 Diabetes (E10-E14),  
 Coronary heart disease (CHD, ICD10: I20-I25),  
 Heart failure (I500, I501, I509),  
 Renal failure (N03, N18, N19, I12, I13),  
 Epilepsy (G40, G41),  
 Asthma (J45, J46),  
 Atrial fibrillation (I48, MS, G35),  
 Cancer (C00-C97),  
 Arthritis (M05, M19, M45, M47, M460-M462, M464, M468, M469),  
 Parkinson's (G20-G22),  
 Chronic liver disease (K711, K713, K714, K717, K754),  
 Congenital problems (Q00-Q99),  
 Diseases of blood and blood forming organs (D50-D89),  
 Other diseases of the digestive system (K00-K122, K130-K839, K85X, K860-K93),  
 Other endocrine metabolic diseases (E00-E07, E15-E35, E70-E90)  
 Admitted to HAH or hospital.

*Selection of patients in the hospital-at-home and control cohorts*

We included patients aged 65 years and older, and who were classified as an unscheduled admission to general or geriatric medicine. In the control cohort, we excluded those with a diagnosis that would not be eligible for management through hospital-at-home; these exclusions included acute intracerebral crisis (intracerebral infections, trauma or haemorrhage), stroke and related codes, acute coronary syndromes and myocardial infarction, surgical emergencies including vascular, urological, gynaecological and general surgical presentations, orthopaedic diagnosis of fractures and trauma, cardiothoracic diagnoses, poisoning and complications of surgery. We also excluded from the control group those who had a diagnosis (i.e. primary and secondary ICD-10 code) that was not observed in any of the hospital-at-home admissions in each site (1081 patients in site one, 1405 in site two and in 451 in site three) (Figure 2). Each patient was counted as a single episode of healthcare.

### *Intervention costs*

We collected data on the costs of hospital-at-home using a template derived from the Cost-It tool of the World Health Organisation.<sup>4</sup> The cost categories included staff, training, transport, information and communication, clinical materials/equipment, support services, laboratory services, diagnostics, overheads and other costs. Clinician managers supported by finance staff in the three Health Boards completed this template based on the actual spending for the hospital-at-home service for the time periods covered by the ISD data. The cost per hospital-at-home admission was calculated by dividing the total costs of the hospital-at-home service by the total number of hospital-at-home admissions during the same period.

### *Statistical analysis*

We used an iterative approach to the analysis, starting with a description of the two cohorts (i.e. those admitted to hospital-at-home and those admitted to hospital) for each Health Board. We calculated means, standard errors, and frequencies to describe differences in patient characteristics at index admission and tested differences using Mann-Whitney test for continuous variables and Chi-square test for categorical variables. We also estimated the mean differences in resource utilisation costs (with bootstrapped standard errors) and the unadjusted relative risk of mortality between the two cohorts for each Health Board.

Further, we investigated the association of being admitted to hospital-at-home or hospital with mortality and cost over a minimum follow-up period of six months. To do this, we followed the Medical Research Council guidelines on performing natural experiments and scientific literature to adopt a step-wise strategy to select the propensity score matching (PSM) technique that most reduced observed confounding between the two cohorts in each Health Board.<sup>5-8</sup> First, we included all possible confounding variables available in the dataset (see Box 2 and Figure 2), and considered that the inclusion of covariates not associated with the treatment assignment would have little influence in the propensity score model.<sup>5</sup> Second, we matched the two cohorts in each site using a range of the most commonly used PSM techniques; these included Mahalanobis, 1-to-1, K-to-1, kernel, local linear regression, spline, and inverse probability weighting techniques. Second, the performance of each PSM technique on covariate balancing was assessed based on the mean and median percentage standardised bias as well as Rubin's B (the absolute standardized difference of the means of the linear index of the propensity score in the treated and (matched) non-treated group) and Rubin's R (the ratio of treated to (matched) non-treated variances of the propensity score index). Following Rubin's (2001) recommendation, we considered B less than 25 and R between 0.5 and 2 to indicate sufficient balance.<sup>9</sup> Third, we chose the PSM technique that had the lowest values on these performance indicators in each of the three Health Boards. We matched the two cohorts in each Health Board by

1  
2  
3 socio-demographic characteristics (i.e. age, gender, socio-economic status), diagnosis code (i.e.  
4 primary and secondary ICD-10 code) of index admission, morbidity (i.e. type of long-term condition,  
5 mortality during follow-up (for the analysis of cost), 2-year costs prior to the index admission (by cost  
6 category as listed in Box 1), and date of index admission (to account for seasonal trends).  
7  
8  
9

10 We performed a doubly robust estimation to further reduce confounding by using a regression  
11 analysis after performing the most suitable PSM technique and including the confounding variables  
12 listed above as covariates.<sup>10</sup> In the regression, we used generalised linear regression models (GLMs)  
13 with gamma distribution and log link to investigate the association of hospital-at-home with total costs  
14 during the follow-up period, and total costs in 6 months following index discharge. We also used GLMs  
15 with Poisson distribution and log link to estimate the relative risk of mortality. Robust standard errors  
16 were specified in all regression models. We calculated Kaplan-Meier survival curves, with and without  
17 using the weights from the PSM, and used log-rank tests to test the equality of the survival functions.  
18 There were few missing observations in the dataset and thus, complete case analysis was performed.  
19  
20  
21  
22  
23  
24  
25

### 26 *Subgroup analysis*

27  
28 We conducted a sub-group analysis, running the same regression models used in the main analysis, to  
29 investigate the association of hospital-at-home services with costs and mortality for the population  
30 who had a diagnosis of dementia. We considered this population to be important due to their complex  
31 healthcare needs, and the increasing prevalence of dementia.<sup>11 12</sup> In a second subgroup analysis, we  
32 excluded patients who died during the follow-up period and investigated the association of hospital-  
33 at-home with costs. In both subgroup analyses, propensity score matching was performed to match  
34 sub-cohorts in each site.  
35  
36  
37  
38  
39

### 40 *Sensitivity analysis*

41  
42 In a univariate sensitivity analysis, we reduced and increased the intervention cost of admission  
43 avoidance hospital-at-home by 50%, as there are no standard unit costs to benchmark these types of  
44 services and we were concerned that costs for these services may vary due to economies of scale,  
45 size, experience, setting, human resource capacity, and error. This sensitivity analysis was expected to  
46 impact the costs during index admission and the costs of admission to hospital-at-home in the six  
47 months after discharge.  
48  
49  
50  
51  
52

### 53 *Patient involvement*

54  
55 Patients were not involved in this retrospective analysis of administrative data.  
56  
57  
58  
59  
60

## Results

### *Characteristics of the population cohorts*

After applying the exclusion criteria, 1737 patients were admitted to hospital-at-home in site one between August 2014 and December 2015 (17 months), 1463 patients were admitted to hospital-at-home in site two between January 2015 and December 2016 (24 months), and 433 patients were admitted to hospital-at-home in site three between August 2014 and December 2015 (17 months) (Figure 2). In the same period, there were 13139 patients admitted to 3 hospitals in site one, 3994 patients admitted to 1 hospital in site two, and 1844 patients admitted to 1 hospital in site three.

There were few differences between the hospital-at-home cohorts in the three sites, the main difference being that a larger proportion of the population in site two lived in a more affluent area (i.e. scored five or higher on the Scottish Index of Multiple Deprivation). Patients admitted to hospital-at-home were on average three to four years older than those admitted to hospital, were more likely to be female (range from 5 percentage points to 9 percentage points), and a higher proportion had more than four long-term conditions (approximately 7 percentage points) compared with patients admitted to hospital (Table 1). The largest difference between those admitted to hospital-at-home and to hospital in site one and site two was in the proportion of patients with dementia (10 percentage points higher in the hospital-at-home cohorts), while in site three it was the proportion of patients with renal failure (also 10 percentage points higher in the hospital-at-home cohort).

We compared the two cohorts in each site, from index admission to six months post discharge from hospital-at-home or hospital (Table 2). There was on average a higher percentage of deaths while receiving healthcare in hospital compared with those receiving healthcare in hospital-at-home (6% vs., 1% site one; 6% vs., 3% site two; 4% vs., 1% site three); and a higher percentage of deaths in the follow-up period, from admission to six months after discharge, in the groups that had received hospital-at-home (21% vs., 28% site one; 22% vs., 32% site two; 17% vs., 27% site three). Patients in the hospital-at-home cohort lived on average eight (site one), ten (site two), and twelve (site three) fewer days during the whole follow-up, and their index admission was on average fewer days in site one (mean unadjusted difference -2.64, 95%CI -2.97 to -2.31) and site three (mean unadjusted difference -2.02, 95%CI -2.66 to -1.37) and longer in site two (mean unadjusted difference 1.25, 95% CI 0.86 to 1.64).

The cost during a hospital-at-home admission was on average lower than hospital admission in site one (mean difference -£2318; 95%CI: £-2420 to £-2217) and site three (mean difference -£1096; 95%CI: £-1398 to £-793), and slightly lower (mean difference £-153; 95%CI: £-277; to £-29) in site two (Table 2). In the hospital-at-home cohort, these costs included the intervention costs of delivering the

1  
2  
3 service at home, which were £628 per admission and £113 per day in site one, £2928 per admission  
4 and £398 per day in site two, and £864.54 per admission and £117.57 per day in site three. In each  
5 Health Board, staff were the major driver of the cost of delivering hospital-at-home (site one 95%, site  
6 two 87%, site three 94%). Detailed information on the costs of delivering hospital at home are in  
7 Appendix 1.  
8  
9

10  
11 Each of the three hospital-at-home cohorts incurred higher healthcare costs, driven by non-elective  
12 hospitalisation, prior to their index admission compared with the respective control cohort. Site one  
13 had on average 40% higher costs (mean difference £3219; 95%CI: £2513 to £3925), site two 56%  
14 higher costs (mean difference £5064; 95%CI: £3984 to £6143) and site three 57% higher costs (mean  
15 difference £4115; 95%CI: £2467 to £5764). In the six months following discharge from the index  
16 admission, costs were higher for each of the three hospital-at-home cohorts; in site one costs were  
17 on average 43% higher (mean difference £1839; 95%CI: £1423 to £2255), in site two they were 16%  
18 higher (mean difference £875, 95%CI: £156 to £1595), and in site three they were 92% higher (mean  
19 difference £3068, 95%CI: £2178 to £3958). The larger increase in costs in all sites was due to higher  
20 non-elective hospitalisation costs in the group who had received hospital-at-home care (mean  
21 difference £1517, 95%CI £1134 to 1899 site one; mean difference £529, 95%CI £-77 to 1135 site two;  
22 mean difference £2618, 95%CI £1779 to 3458 site three) during the six months follow-up.  
23  
24  
25  
26  
27  
28  
29  
30  
31

32 When the cost of the index admission was included in the analysis, the cost during follow-up (i.e.  
33 including the index admission and 6-months healthcare resource use after index discharge) was 6%  
34 lower (mean difference -£480, 95%CI: £-996 to £36) in the hospital-at-home cohort, compared with  
35 the control cohort in site one; while these costs were 8% higher in site two (mean difference £722,  
36 95%CI: £32 to £1413) and 35% higher in site three (mean difference £1973, 95%CI: £1019 to £2927).  
37  
38  
39  
40

41 Compared with the control cohort, the mean costs per day of being alive during the follow-up period  
42 were 13% (mean difference £-12; 95%CI: -17 to -6) lower in the hospital-at-home cohort in site one,  
43 while these costs were 34% higher (mean difference £37; 95%CI: 18 to 56) and 66% higher (mean  
44 difference £36; 95%CI: 18 to 53) in site two and site three respectively.  
45  
46  
47  
48  
49  
50

51 Figure 2 Flowchart of study population  
52  
53  
54  
55  
56  
57  
58  
59  
60

Table 1 Patient characteristics at index admission

Variable	Site one		Site two		Site three	
	Control (n=13139)	HAH (n=1737)	Control (n=3994)	HAH (n=1463)	Control (n=1844)	HAH (n=433)
Mean age on admission (se)	77.8 (0.07)	81.2 (0.17)**	78.5 (0.13)	82.2 (0.21)**	77.3 (0.18)	81.4 (0.34)**
Female	7,468 (57%)	1,096 (63%)**	2,102 (53%)	909 (62%)**	1037 (56%)	266 (61%)*
Higher than 4 on the SIMD	5,005 (38%)	609 (35%)**	1,960 (49%)	775 (53%)*	837 (45%)	192 (44%)
More than 4 chronic conditions	4,974 (38%)	777 (45%)**	1,664 (42%)	725 (50%)**	659 (36%)	185 (43%)**
Arthritis	3,431 (26%)	497 (29%)*	1,455 (37%)	572 (39%)	606 (33%)	155 (36%)
Asthma	1,370 (10%)	183 (11%)	497 (13%)	207 (14%)	177 (10%)	49 (11%)
Atrial fibrillation	3,659 (28%)	488 (28%)	1,555 (29%)	468 (32%)*	498 (27%)	126 (29%)
Cancer	3,749 (29%)	485 (28%)	1,261 (32%)	371 (25%)**	580 (31%)	124 (29%)
CVD	2,922 (22%)	467 (27%)**	763 (19%)	392 (27%)**	373 (20%)	114 (26%)**
Liver disease	499 (4%)	50 (3%)	183 (5%)	52 (4%)	72 (4%)	20 (5%)
COPD	3,641 (28%)	505 (29%)	1,083 (27%)	428 (29%)	510 (28%)	132 (31%)
Dementia	1,999 (15%)	439 (25%)**	665 (17%)	390 (27%)**	223 (12%)	74 (17%)**
Diabetes	2,985 (23%)	403 (23%)	948 (24%)	350 (24%)	410 (22%)	115 (27%)*
Epilepsy	459 (4%)	75 (4%)	146 (4%)	78 (5%)**	53 (3%)	10 (2%)
CHD	5,034 (38%)	733 (42%)**	1,425 (36%)	575 (39%)*	624 (34%)	141 (33%)
Heart failure	2,197 (17%)	404 (23%)**	744 (19%)	32 (23%)**	328 (18%)	109 (25%)**
MS	73 (1%)	6 (0%)	21 (1%)	17 (1%)*	14 (1%)	2 (1%)
Parkinson's	293 (2%)	66 (4%)**	82 (2%)	53 (4%)**	53 (3%)	20 (5%)
Renal failure	2,501 (19%)	394 (23%)**	780 (20%)	339 (23%)**	284 (15%)	110 (25%)**
Congenital problems	277 (2%)	38 (2%)	159 (4%)	51 (4%)	51 (3%)	9 (2%)
Diseases of blood	3,784 (29%)	553 (32%)**	1,143 (29%)	426 (29%)	485 (26%)	125 (29%)
Endocrine metabolic disease	4,505 (34%)	624 (36%)	1,737 (44%)	652 (45%)	642 (35%)	151 (35%)
Disease of digestive system	9,341 (71%)	1,249 (72%)	2,710 (68%)	1,006 (69%)	1145 (62%)	286 (66%)

\* p<0.05 \*\* p<0.01 in chi-square test for categorical and Mann-Whitney for continuous variables to test differences between HAH and control; HAH: hospital-at-home; SIMD ranges from 1 (most deprived) to 10 (most affluent); Note: a patient could be registered with more than one ICD-10 codes;

Table 2. Mortality, resource utilisation and costs

Variable	Site one			Site two			Site three		
	Control (n=13139)	HAH (n=1737)	Mean difference or risk ratio (95%CI)	Control (n=3994)	HAH (n=1463)	Mean difference or risk ratio (95%CI)	Control (n=1844)	HAH (n=433)	Mean difference or risk ratio (95%CI)
Died during index admission	844 (6%)	20 (1%)	0.18 (0.12;0.28)##	256 (6%)	47 (3%)	0.50 (0.37;0.68)##	78 (4%)	2 (1%)	0.11 (0.03;0.44)##
Died during follow-up including index admission	2,787 (21%)	483 (28%)	1.31 (1.21;1.42)##	867 (22%)	471 (32%)	1.48 (1.35;1.63)##	319 (17%)	116 (27%)	1.55 (1.29;1.86)##
Means days alive during follow-up (se)	159 (0.50)	151 (1.45)	-8.32 (-11.32;-5.32)	156 (0.91)	146 (1.72)	-10.10 (-14;-7)	163 (1.22)	151 (2.88)	-12 (-18;-6)
Mean length of index admission in days (se)	8.18 (0.12)	5.54 (0.13)	-2.64 (-2.97;-2.31)	6.10 (0.14)	7.35 (0.14)	1.25 (0.86;1.64)	6.36 (0.26)	4.34 (0.20)	-2.02 (-2.66;-1.37)
Mean 2 year historical costs (se)									
A&E	173 (2)	253 (7)	80 (65;94)	136 (4)	180 (6)	44 (28;60)	143 (5)	202 (12)	59 (31;87)
Elective hospital care	985 (37)	956 (134)	-28 (-352;295)	1,027 (64)	705 (86)	-321 (-519;-123)	981 (87)	1036 (372)	55 (-723;833)
Non-elective hospital care	4,037 (79)	6,945 (266)	2908 (2452;3364)	5,101 (185)	9,593 (394)	4492 (3804;5179)	3978 (211)	7832 (614)	3854 (2591;5118)
Hospital day case	707 (25)	439 (32)	-269 (-340;-197)	625 (66)	290 (44)	-336 (-479;-193)	544 (49)	358 (55)	-186 (-334;-38)
Geriatric long stay	360 (27)	504 (82)	143 (-66;354)	117 (29)	252 (72)	135 (-13;283)	105 (31)	229 (59)	125 (14;235)
Mental ward	247 (32)	367 (117)	119 (-177;411)	347 (79)	1,053 (205)	706 (265;1147)	220 (75)	252 (139)	32 (-329;393)
Outpatient	173 (2)	173 (5)	0 (-11;11)	222 (4)	206 (6)	-15 (-30;0)	212 (6)	201 (12)	-11 (-38;15)
Medication (GP prescriptions)	1,468 (15)	1,733 (43)	256 (187;341)	1,524 (28)	1,883 (52)	360 (253;466)	1034 (39)	1221 (78)	188 (30;346)
Total	8,149 (109)	11,369 (359)	3219 (2513;3925)	9,098 (239)	14,162 (477)	5064 (3984;6143)	7217 (267)	11333 (772)	4115 (2467;5764)
Mean costs during index admission (se)	3,195 (41)	877# (32)	-2318 (-2420;-2217)	3,426 (71)	3,273# (32)	-153 (-277;-29)	2383 (90)	1287 (132)	-1096 (-1398;-793)
Mean costs 6 months after index discharge (se)									
A&E	72 (1)	88 (3)	17 (11;22)	55 (2)	53 (3)	-2 (-9;4)	59 (2)	71 (5)	12 (-1;25)
Elective hospital care	305 (20)	157 (40)	-148 (-236;-60)	272 (28)	204 (50)	-68 (-190;53)	169 (33)	313 (117)	144 (-92;380)
Non-elective hospital care	2,444 (51)	3,961 (171)	1517 (1134;1899)	3,942 (130)	4,471 (251)	529 (-77;1135)	2029 (123)	4648 (421)	2618 (1779;3458)
Hospital day case	237 (11)	73 (11)	-164 (-191;-138)	234 (24)	96 (21)	-139 (-198;-79)	168 (23)	63 (15)	-105 (-162;-48)
Geriatric long stay	643 (45)	1,014 (131)	371 (79;663)	218 (34)	150 (46)	-68 (-178;41)	320 (56)	700 (186)	381 (-73;834)
Mental ward	165 (22)	206 (51)	41 (-58;140)	299 (56)	259 (77)	-40 (-224;143)	211 (65)	120 (62)	-91 (-245;64)
Outpatient	54 (1)	45 (2)	-9 (-13;-5)	61 (2)	54 (3)	-8 (-14;-2)	65 (3)	67 (6)	2 (-12;16)
Medication (GP prescriptions)	392 (5)	415 (13)	23 (-5;52)	402 (9)	482 (16)	80 (45;115)	314 (12)	338 (27)	24 (-28;76)
Hospital-at-home	4 (1)	196 (11)	193 (170;216)	50 (7)	642 (45)	592 (506;679)	7 (1)	90 (12)	83 (59;108)
Total	4,316 (78)	6,155 (240)	1839 (1423;2255)	5,535 (154)	6,410 (286)	875 (156;1595)	3342 (163)	6410 (510)	3068 (2178;3958)
Mean costs in follow-up (se) including index admission	7,513 (92)	7,031 (243)	-480 (-996;36)	8,961 (180)	9,683 (290)	722 (32;1413)	5724 (199)	7697 (521)	1973 (1019;2927)
Mean costs per lived day in follow-up (se)	83 (1)	72 (3)	-12 (-17;-6)	109 (3)	146 (8)	37 (18;56)	55 (2)	91 (8)	36 (18;53)

# it includes the interventions costs (i.e. £628 in site one, £2,928 in site two, and £865.54 in site three) and other costs occurred during the episode; ## Unadjusted Risk Ratio;

### *Selection of propensity score matching technique*

In the propensity score matched analysis, there were 1696, 925, and 427 patients in the hospital-at-home cohort and 11571, 3849, and 1683 patients in the hospital cohort in site one, site two, and site three respectively (Figure 2). Local linear regression matching was the best PSM technique to match the cohorts in site one and site three for costs and mortality, as it resulted in a lower mean (i.e. 1.5 and 1.8 respectively) and median (i.e. 1.2 and 1.6 respectively) percentage standardised bias, as well as the lowest Rubin's B (i.e. 9.4 and 9.6 respectively). Based on the same criteria, Kernell matching was selected to match the cohorts in site two. Rubin's R was within the suggested range (i.e. from 0.5 to 2) in the selected techniques. These results as well as the patient characteristics at index admission after propensity score matching are presented in Appendix 2. As this Appendix shows, the differences in patient characteristics between the compared cohorts were almost eliminated after propensity score matching.

### *Main propensity score matched analysis*

The results of the main analysis are presented in Panel A in Table 3. After propensity score matching and regression analysis, the healthcare cost for site one in hospital-at-home during the whole follow-up period (i.e. during index admission and over six months after discharge from the index admission) was on average 18% lower (ratio of means: 0.82; 95%CI: 0.76 to 0.89) than admission to hospital. When the cost of the index admission was excluded from the hospital-at-home and hospital cohorts, costs were on average 27% higher (ratio of means: 1.27; 95%CI: 1.14 to 1.41) for hospital-at-home compared with hospital in site one. In site two, the difference in costs between the hospital-at-home and hospital was close to zero (ratio of means: 1.00; 95%CI 0.92 to 1.09) during the whole follow-up period and 9% higher (ratio of means: 1.09; 95%CI: 0.95 to 1.24) when the cost of the index admission was excluded. In site three, patients admitted to hospital-at-home had on average 15% higher cost during the whole follow-up period (ratio of means: 1.15; 95%CI 0.99 to 1.33) and 70% higher cost when the cost of the index admission was excluded (ratio of means: 1.70; 95%CI 1.40 to 2.07) compared with patients admitted to hospital. The full results of the regression analyses are presented in Appendix 3.

There may be an increased risk of mortality in all three hospital-at-home cohorts (site one: relative risk 1.09; 95%CI 1.00 to 1.19) (site two: relative risk 1.29; 95%CI: 1.15 to 1.44) (site three: relative risk 1.27; 95%CI: 1.06 to 1.54) compared with the hospital cohort after PSM and regression were performed to adjust for confounding. The Kaplan-Meier survival curves presented in Figure 3 show higher survival rates in the inpatient control cohorts in all three sites, and after weighting with the propensity score the control cohort in site two continued to have a higher survival rate than the hospital-at-home cohort. The difference in survival in site three between the results reported in Table



3 and the survival curve after weighting is explained by the fact that Kaplan-Meier curves are only weighted with the propensity score without performing an additional regression analysis.

Table 3. Results of the propensity score matched regression analyses

Panel A: main analysis			
Outcome variable	Site one (n=13267)	Site two (n=4769)	Site three (n=2110)
Total costs during follow-up period <sup>#</sup>	0.82 (0.03) [0.76;0.89] <0.001	1.00 (0.05) [0.92;1.09] 0.982	1.15 (0.09) [0.99;1.33] 0.073
Total costs in 6 months after discharge	1.27 (0.07) [1.14;1.41] <0.001	1.09 (0.07) [0.95;1.24] 0.219	1.70 (0.17) [1.40;2.07] <0.001
Mortality rate during follow-up	1.09 (0.05) [1.00;1.19] 0.059	1.29 (0.07) [1.15;1.44] <0.0010	1.27 (0.12) [1.06;1.54] 0.011
Panel B: subgroup analysis including only patients with dementia			
Outcome variable	Site one (n=2321)	Site two (n=1053)	Site three (n=280)
Total costs during follow-up period <sup>#</sup>	0.76 (0.05) [0.66;0.87] <0.001	0.76 (0.06) [0.66;0.88] <0.001	0.87 (0.15) [0.63;1.21] 0.409
Total costs in 6 months after discharge	1.18 (0.11) [0.99;1.41] 0.071	0.75 (0.09) [0.59;0.96] 0.021	1.58 (0.41) [0.95;2.63] 0.078
Mortality rate during follow-up	1.05 (0.09) [0.89;1.24] 0.594	1.41 (0.12) [1.19;1.67] <0.001	1.65 (0.32) [1.12;2.41] 0.011
Panel C: subgroup analysis including only survivors			
Outcome variable	Site one (n=10132)	Site two (n=3584)	Site three (n=1691)
Total costs during follow-up period <sup>#</sup>	0.85 (0.04) [0.77;0.94] 0.002	1.11 (0.03) [1.00;1.25] 0.058	1.20 (0.11) [1.00;1.43] 0.046
Total costs in 6 months after discharge	1.23 (0.08) [1.08;1.40] 0.002	1.17 (0.10) [0.99;1.38] 0.070	1.71 (0.20) [1.36;2.15] <0.001
Panel D: sensitivity analysis			
Outcome variable	Site one (n=13267)	Site two (n=4769)	Site three (n=2110)
Total costs during follow-up period <sup>#</sup> (assuming 50% lower intervention costs)	0.77 (0.03) [0.71;0.84] <0.001	0.81 (0.04) [0.74;0.9] 0.001	1.07 (0.09) [0.91;1.25] 0.399
Total costs during follow-up period <sup>#</sup> (assuming 50% higher intervention costs)	0.87 (0.03) [0.81;0.94] 0.001	1.18 (0.05) [1.09;1.28] <0.001	1.23 (0.09) [1.07;1.42] 0.004

<sup>#</sup> It includes the index admission period and 6 months post-discharge; Note: The results are presents as coefficient (se) [95%CI] p value; The results are after matching and adjusting for age, gender, socio-economic status, primary and secondary ICD-10 codes of index admission, type of long-term condition, mortality (for the analysis of costs), 2-year costs prior to the index admission (by cost category as listed in Box 1).

Figure 3. Survival curves before and after propensity score matching

### Results of the subgroup analysis

Patients with dementia (Panel B in Table 3) admitted to hospital-at-home services in site one and site two had an average of 24% lower costs (site one: ratio of means 0.76; 95%CI 0.66 to 0.87; site two: ratio of means 0.76 95%CI: 0.66 to 0.88) from the index admission to six months post-discharge. We found that the population who were admitted to hospital-at-home, and had a diagnosis of dementia, may have an increased risk of death (site one: 1.05, 95% CI 0.89 to 1.24; site two: relative risk 1.41, 95%CI 1.19 to 1.67; site three: relative risk 1.65, 95%CI 1.12 to 2.41) compared with those who had a diagnosis of dementia and who were admitted to hospital.

When we excluded people who died during follow-up (i.e. during index admission and 6 months after discharge), patients admitted to hospital-at-home in site one had lower costs (ratio of means 0.85, 95%CI: 0.77 to 0.94), while there was 11% increase in costs in site two (ratio of means 1.11, 95%CI: 1.00 to 1.25) and 20% increase in site three (ratio of means 1.20, 95%CI: 1.00 to 1.43); the mean costs were higher in the hospital-at-home cohort when the costs during the index admission were excluded (site one: ratio of means 1.23, 95%CI: 1.08 to 1.40; site two: ratio of means 1.17, 95% CI 0.99 to 1.38; site three: ratio of means 1.71, 95% CI 1.36 to 2.15) compared with patients admitted to hospital (Panel C in Table 3).

### *Results of the sensitivity analyses*

The results from the sensitivity analysis (Panel D in Table 3) showed that patients in the hospital-at-home cohort in site one had 13% lower costs (ratio of means 0.87; 95%CI: 0.81 to 0.94) during the follow-up period (i.e. during index admission and 6 months after index discharge) when the hospital-at-home service costs were assumed to be 50% higher than in the main analysis. In site two, the results from the sensitivity analysis showed that the uncertainty in hospital-at-home service costs lead to increased costs or cost savings by about 18% (ratio of means 1.18; 95%CI: 1.09 to 1.28) during the whole follow-up period. In site three, the sensitivity analysis showed a 23% cost increase (ratio of means 1.23; 95%CI: 1.07 to 1.42), if the intervention costs of hospital-at-home were 50% higher.

## Discussion

### *Main findings*

Patients who received healthcare from the hospital-at-home services were older, were more socioeconomically disadvantaged, had higher morbidity (measured by the number of long term conditions), higher rates of previous hospitalisation, and there was a greater proportion of women compared with the group admitted to hospital. The two groups also differed in terms of their clinical diagnosis, with the most marked difference across the three services being a greater percentage (five to ten percent difference) of people with dementia. The higher healthcare costs over the two years prior to index admission in those admitted to hospital-at-home were mainly driven by the costs of non-elective hospitalisation. However, the differences in patient characteristics were almost eliminated after propensity score matching. The cost of providing hospital-at-home varied between the three sites from £628 to £2928 per admission, and costs were driven primarily by staff costs. Our findings indicate that hospital-at-home might be associated with an increase in healthcare costs in the six months after index discharge. However, this increase in costs might be offset by likely cost-savings during the index admission. The higher healthcare cost at six months after index discharge, was driven primarily by acute non-elective hospitalisation. Interpreting this is not straightforward; it might indicate a lack of resources during the index admission to hospital-at-home, or an increased risk of hospital admission in the population who receive their healthcare through hospital-at-home. The suggestion of an increased risk of mortality at six months after the index admission might be genuine, or could indicate that propensity score matching did not control for all differences between the groups and thus, the estimates are subject to residual confounding.<sup>13 14</sup>

### *Comparison with previous studies*

A meta-analysis of six small randomised controlled trials concluded that admission avoidance hospital-at-home probably makes little or no difference to the risk of death or transfer to hospital at six months' follow-up, and might increase the likelihood of living at home (albeit with low-certainty evidence); and highlighted the lack of evidence on cost.<sup>2</sup> Studies that have used 'real life data' offer the potential to address criticisms of limited external validity from randomised trials; and propensity score matching is one technique that has been used to balance co-variables when analysing routinely collected health data to assess these type of service delivery interventions. Findings have been consistent, and previous studies have reported higher rates of mortality and unplanned admission for those who received an intermediate care intervention, compared with matched controls.<sup>6 14 15</sup> However, it is possible that these findings are subject to residual confounding.

### *Potential mechanisms and interpretation*

Healthcare services that cross the interface of primary and secondary care can bridge and strengthen the integration of acute and community services, and social care. However, by definition this can lead to a complex arrangement of services that reflect availability of local resources,<sup>16</sup> and a willingness to innovate. The hospital-at-home services evaluated in this analysis were established to reduce the demand for acute hospital beds by providing an alternative to admission to hospital, and to lower the risk of functional decline from the limited mobility that older people might experience when in hospital. However, it is possible that the services have several functions, for example by providing both rapid response and reablement, and this is reflected in the diverse population included in this analysis. Existing services and the overall structure of the healthcare care system in Scotland may also have influenced the shape and scope of hospital-at-home functions. Regarding the control cohorts, older people admitted to acute hospital in Scotland receive quite variable care and access to comprehensive geriatric assessment depending on whether they are placed in a geriatric medical unit or other environments such as general adult medicine. This variation may also have influenced the results of this study.

### *Implications for clinicians and policy makers*

The variation in intervention costs of the three hospital-at-home services is primarily driven by staff costs, and the findings of the sensitivity analysis confirms that staff costs are likely to determine whether a hospital-at-home service leads to higher costs or cost savings. The skill-mix of healthcare professionals who provide hospital-at-home should be guided by national standards, the type of patients the service targets, and the function of the service in terms of whether or not the service supplements existing community based healthcare, substitutes for hospital level care, augments palliative care services or a combination of these. The integration of these types of service with

1  
2  
3 existing primary and secondary care services, for example the provision of out-of-hours care by  
4 primary care services, might also determine the costs of these services. Managerial capacity of these  
5 services is expected to be of crucial importance in setting-up and managing the team of professionals  
6 able to provide high quality care.  
7  
8  
9

10 The absence of evidence based guidelines about who and under which conditions a patient may be  
11 admitted to admission avoidance hospital-at-home might explain the variation in the set-up of  
12 services, the difference in patient characteristics between patients admitted to hospital-at-home and  
13 hospital, and the relatively small size of the services. This is confirmed by the National Audit of  
14 Intermediate Care,<sup>17</sup> that was established in response to concerns about governance structures in  
15 intermediate care services, and reported a complex pattern of service provision.  
16  
17  
18  
19

20 Data on the role and capability of informal care givers is largely absent. In many cases, people admitted  
21 to hospital-at-home services receive care from their partners who if old might have health issues  
22 themselves.  
23  
24  
25

### 26 *Strengths and limitations*

27

28 The strengths of this study include the dataset from three of the largest Health Boards in Scotland, the  
29 quasi-experimental study design that has allowed inferences from real world evidence, and the  
30 sensitivity analyses that helped to address uncertainty in the results. The major limitation of this type  
31 of non-randomised comparison is residual confounding. While matching individuals and performing  
32 regression analysis can reduce this risk, it is possible that the two populations differed in frailty  
33 because we did not match and adjust for differences in the use of community and social services prior  
34 to index admission. If unobserved confounders were part of the clinical-decision making by GPs and  
35 geriatricians to admit patients to hospital-at-home or hospital, our findings might be biased due to  
36 confounding by clinical indication. This type of confounding is often not measured directly because  
37 standardised criteria are not available to guide clinical decision-making.<sup>18 19</sup> Therefore, the magnitude  
38 of this bias in our results depends on the clinical-decision making process to admit patients to hospital-  
39 at-home in the three sites. If clinicians did not consider hospital-at-home as a substitute service to  
40 hospitalisation then confounding by indication would increase the residual confounding in our  
41 analysis. GPs and geriatricians who refer patients to hospital-at-home are likely to have a clinical bias  
42 in preferring to keep older, frailer and terminally ill patients in their own home. Using hospital-at-  
43 home admission criteria to define the control cohort accepts that such open criteria will include  
44 general medical patients who are likely to have fewer comorbidities, be younger and with a longer life  
45 expectancy. However, as the results of the survivors' subgroup analysis were very similar with the  
46 results of the main cost analysis we expect that the magnitude of the residual confounding to be small.  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 Furthermore, the use of routine data has been used to reliably identify older people with frailty,<sup>20</sup> and  
4 approaches using clinical codes to define this population are being tested.<sup>21</sup>  
5  
6

### 7 *Future research*

8

9 Guidance on the use of real life data to evaluate service delivery interventions is largely absent, and  
10 could provide healthcare decision-makers with a relatively inexpensive way of evaluating local service  
11 innovations and how to avoid pitfalls in analysis and interpretations. Similar to all observational  
12 studies, the findings of this study may be used to identify important questions to be tested in  
13 randomised trials.<sup>18</sup> A multi-centre randomised trial that measures outcomes that are key to decision-  
14 makers (including informal care giving), and is accompanied by a process evaluation to help explain  
15 the findings, is necessary to provide clinicians and policy makers with further evidence about the  
16 effectiveness and cost-effectiveness of admission avoidance hospital-at-home services across UK. The  
17 authors are involved in such a trial the results of which are expected to be available in 2019.<sup>22</sup>  
18  
19  
20  
21  
22  
23  
24  
25

## 26 **Conclusions**

27

28 We found differences in the populations admitted to hospital-at-home and hospital. The likely higher  
29 cost in all three hospital-at-home cohorts, compared with the hospital cohorts during the six months  
30 following discharge, highlights the importance of characterising populations eligible to receive these  
31 types of healthcare services and of assessing subsequent use of health, social, and informal care  
32 following admission to hospital-at-home or hospital. The lack of data on the severity of the observed  
33 acute and chronic conditions as well as on type of hospitalised care received in the control cohorts  
34 means that we cannot rule out the risk of residual confounding, and the findings should be interpreted  
35 with caution.  
36  
37  
38  
39  
40  
41  
42

## 43 **Competing interests**

44

45 All authors have completed the ICMJE uniform disclosure form. GE is leading one of the hospital-at-  
46 home services in this study. All other authors declare no support from any organisation for the  
47 submitted work; no financial relationships with any organisations that might have an interest in the  
48 submitted work in the previous three years; no other relationships or activities that could appear to  
49 have influenced the submitted work.  
50  
51  
52  
53  
54  
55

## 56 **Details of contributors**

57

58 AT, GE, and SS were responsible for study concept, GE and SB facilitated the acquisition of data; AT  
59 and SS led the writing of the protocol, study design and drafting of the manuscript; AT performed the  
60

1  
2  
3 statistical analysis. PL and DS provided clinical expertise and commented on previous versions of the  
4 manuscript. All authors interpreted the data, critically revised the manuscript for important  
5 intellectual content and approved the final version for submission. AT and SS are guarantors.  
6  
7  
8  
9  
10

## 11 Acknowledgement

12  
13  
14 We would like to thank Charmaine Walker, Jenny Boyd, Alistair Smith and Josh Matthews from ISD  
15 Scotland for providing us with the data as well as Christine McGregor (economist in the Scottish  
16 Government) for her insightful views and expertise. We are also indebted to Dr Mike Gardner and Prof  
17 Alastair Gray (both University of Oxford), Prof Stavros Petrou (University of Warwick), and Dr Matthew  
18 Sperrin (University of Manchester) for commenting on previous drafts of the manuscript. Our thanks  
19 also to Prof Gillian Parker (University of York), Dr Angela Coulter (University of Oxford) and Prof Stuart  
20 Parker (University of Newcastle) for their useful reflection on the study findings. Finally, we would like  
21 to thank all healthcare staff in all three sites who made this study happen.  
22  
23  
24  
25  
26  
27  
28

## 29 Ethical approval

30  
31  
32 We obtained local data transfer agreements and signed release forms from each Health Board's  
33 Caldicott guardian. Further approval from an ethics committee was not required because the study  
34 was part of a service audit and the data provided to the researchers was de-identified.  
35  
36  
37  
38

## 39 Funding

40  
41  
42 NIHR, UK. (12/5003//01; "How to Implement Cost-Effective Comprehensive Geriatric Assessment")  
43  
44

## 45 Data sharing agreement

46  
47  
48 No additional data are available.  
49  
50

## 51 References

- 52  
53  
54  
55 1. World Health Organization. Noncommunicable diseases progress monitor 2015. Geneva: World  
56 Health Organization, 2015.  
57 2. Shepperd S, Iliffe S, Doll HA, et al. Admission avoidance hospital at home. *Cochrane Database Syst*  
58 *Rev* 2016;9:CD007491. doi: 10.1002/14651858.CD007491.pub2  
59 3. Sherman RE, Anderson SA, Dal Pan GJ, et al. Real-World Evidence - What Is It and What Can It Tell  
60 Us? *N Engl J Med* 2016;375(23):2293-97. doi: 10.1056/NEJMs1609216

- 1
  - 2
  - 3
  4. Johns B, Baltussen R, Hutubessy R. Programme costs in the economic evaluation of health interventions. *Cost effectiveness and resource allocation : C/E* 2003;1(1):1.
  - 5
  - 6
  - 7
  - 8
  - 9
  - 10
  - 11
  - 12
  - 13
  - 14
  - 15
  - 16
  - 17
  - 18
  - 19
  - 20
  - 21
  - 22
  - 23
  - 24
  - 25
  - 26
  - 27
  - 28
  - 29
  - 30
  - 31
  - 32
  - 33
  - 34
  - 35
  - 36
  - 37
  - 38
  - 39
  - 40
  - 41
  - 42
  - 43
  - 44
  - 45
  - 46
  - 47
  - 48
  - 49
  - 50
  - 51
  - 52
  - 53
  - 54
  - 55
  - 56
  - 57
  - 58
  - 59
  - 60
5. Stuart EA. Matching methods for causal inference: A review and a look forward. *Statistical science : a review journal of the Institute of Mathematical Statistics* 2010;25(1):1-21. doi: 10.1214/09-STS313
  6. Garrido MM, Kelley AS, Paris J, et al. Methods for constructing and assessing propensity scores. *Health Serv Res* 2014;49(5):1701-20. doi: 10.1111/1475-6773.12182
  7. Baser O. Too much ado about propensity score models? Comparing methods of propensity score matching. *Value Health* 2006;9(6):377-85. doi: 10.1111/j.1524-4733.2006.00130.x
  8. Craig P, Cooper C, Gunnell D, et al. Using natural experiments to evaluate population health interventions: new Medical Research Council guidance. *J Epidemiol Community Health* 2012;66(12):1182-6. doi: 10.1136/jech-2011-200375
  9. Rubin DB. Using propensity scores to help design observational studies: application to the tobacco litigation. *Health Services & Outcomes Research Methodology* 2001;2:169-88.
  10. Funk MJ, Westreich D, Wiesen C, et al. Doubly robust estimation of causal effects. *Am J Epidemiol* 2011;173(7):761-7. doi: 10.1093/aje/kwq439
  11. Leist AK. Social Inequalities in Dementia Care, Cure, and Research. *J Am Geriatr Soc* 2017;65(5):1100-01. doi: 10.1111/jgs.14893
  12. World Health Organization. Draft global action plan on the public health response to dementia, 2016.
  13. Iliffe S. Hospital at home: from red to amber?. Data that will reassure advocates-but without satisfying the sceptics. *Bmj* 1998;316(7147):1761-2.
  14. Steventon A, Bardsley M, Billings J, et al. The role of matched controls in building an evidence base for hospital-avoidance schemes: a retrospective evaluation. *Health Serv Res* 2012;47(4):1679-98. doi: 10.1111/j.1475-6773.2011.01367.x
  15. Lewis G, Vaithianathan R, Wright L, et al. Integrating care for high-risk patients in England using the virtual ward model: lessons in the process of care integration from three case sites. *Int J Integr Care* 2013;13:e046.
  16. Young J, Gladman JR, Forsyth DR, et al. The second national audit of intermediate care. *Age Ageing* 2015;44(2):182-4. doi: 10.1093/ageing/afu174
  17. NHS Benchmarking Network. Summary report- England. National audit of intermediate care: NHS Benchmarking Network, 2017.
  18. Freemantle N, Marston L, Walters K, et al. Making inferences on treatment effects from real world data: propensity scores, confounding by indication, and other perils for the unwary in observational research. *Bmj* 2013;347:f6409. doi: 10.1136/bmj.f6409
  19. Wong AY, Root A, Douglas IJ, et al. Cardiovascular outcomes associated with use of clarithromycin: population based study. *Bmj* 2016;352:h6926. doi: 10.1136/bmj.h6926
  20. Clegg A, Bates C, Young J, et al. Development and validation of an electronic frailty index using routine primary care electronic health record data. *Age Ageing* 2017 doi: 10.1093/ageing/afx001
  21. Ham C, York N, Sutch S, et al. Hospital bed utilisation in the NHS, Kaiser Permanente, and the US Medicare programme: analysis of routine data. *Bmj* 2003;327(7426):1257. doi: 10.1136/bmj.327.7426.1257
  22. Shepperd S, Craddock-Bamford A, Butler C, et al. A multi-centre randomised trial to compare the effectiveness of geriatrician-led admission avoidance hospital at home versus inpatient admission. *Trials* 2017;18(1):491. doi: 10.1186/s13063-017-2214-y

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

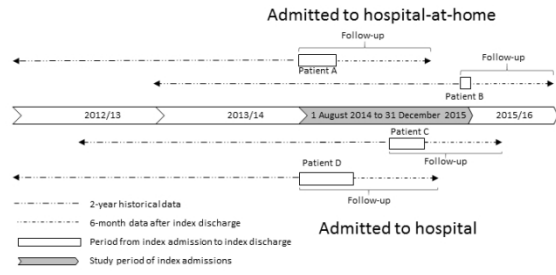


Figure 1. Illustration of obtained data from site one  
338x190mm (96 x 96 DPI)



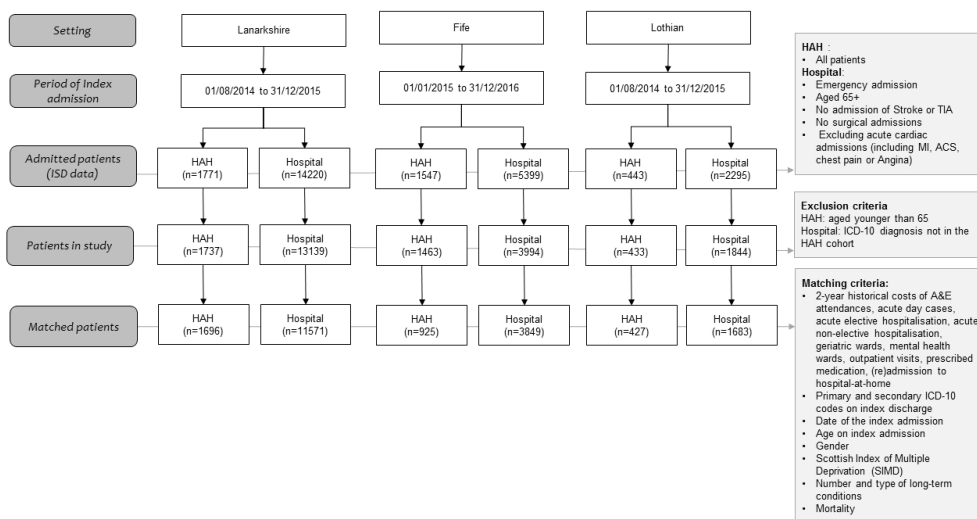
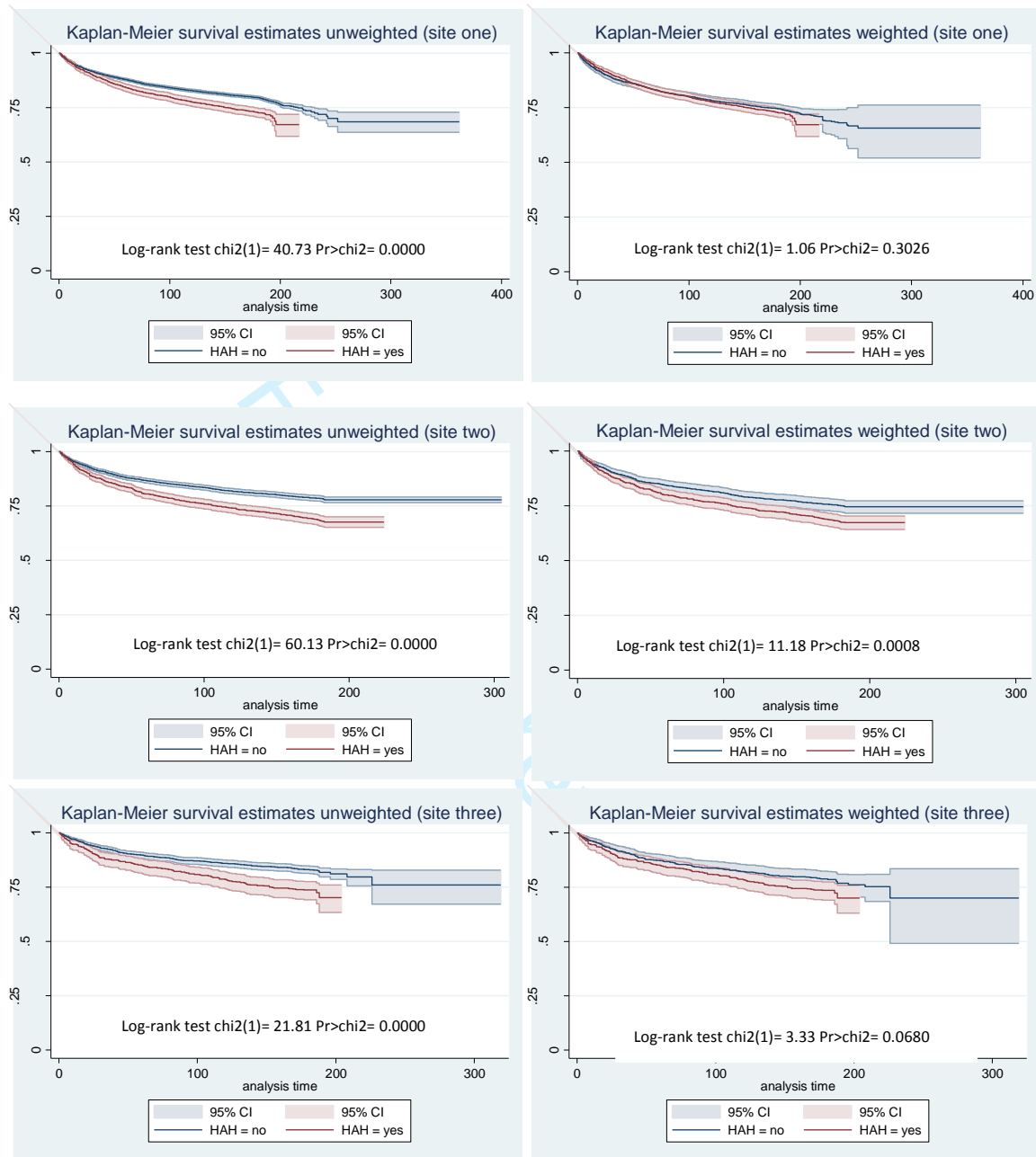


Figure 2 Flowchart of study population

338x190mm (96 x 96 DPI)

Figure 3. Survival curves before and after propensity score matching



Note: The cohorts in each site were matched on age, gender, socio-economic status, primary and secondary ICD-10 codes of index admission, type of long-term condition, 2-year costs prior to the index admission (by cost category as listed in Box 1); Weighted refers to weighting the observation of each patient based on the propensity score to be in the hospital-at-home cohort as described in the propensity score matching section.

Appendix 1. Calculation of admission avoidance hospital-at-home in each site

Site one		PERIOD				
from:	01/08/2014 (dd/mm/yyyy)	Until:	01/01/2016 (dd/mm/yyyy)			
		17 Months				
		Source of				
Number of HAH admissions (in period)	1771	ISD IPD data (1/8/14-31/12/15)				
Length of HAH stay per episode (in	5.53886 Mean 0.125605 Standard error	ISD IPD data (1/8/14-31/12/15)				
HAH bed days (period)	9809					
<b>A.1. Staff costs</b>						
No	Profession	WTEs	Gross	Summary salary	Source of	Total
<b>a) Medical staff</b>						
1	Consultant	1.50	£151,596		Business	£227,394
2	Agency consultant	0.16	£156,926		Business	£25,651
3	Consultant	1.07	£119,710		Business	£127,767
<b>b) Nursing and pharmacy services</b>						
1	Band 3 nurse	3.00	£24,790		Business	£74,369
2	Band 6 nurse	1.49	£41,425		Business	£61,740
3	Band 5 Bank nurse	0.71	£32,885		Business	£23,399
4	Band 6 Bank nurse	0.36	£38,471		Business	£13,687
5	Band 7 pharmacist	0.71	£55,491		Business	£39,484
6	Band 5 nurse	0.16	£37,036		Business	£6,054
7	Band 6 nurse	1.42	£42,342		Business	£60,303
8	Band 7 nurse	1.00	£42,444		Business	£42,444
9	Band 8a nurse	0.71	£53,126		Business	£37,801
<b>c) Allied health professions</b>						
1	Band 6 occupational therapist	2.59	£35,489		Business	£91,793
2	Band 6 physiotherapist	1.16	£46,585		Business	£54,200
3	Band 4 assistant practitioners for rehab	3.59	£24,660		Business	£88,444
4	Band 6 physiotherapy	0.71	£46,848		Business	£33,334
<b>d) Administration, ICT and management</b>						
1	Band 2 admin/clerical	0.30	£19,346		Business	£5,804
2	Band 3 admin/clerical	1.00	£23,948		Business	£23,948
3	Band 3 admin/clerical	0.71	£21,353		Business	£15,193
<b>e) Support services staff</b>						
1						£0
<b>Total</b>						<b>£1,052,80</b>
<b>A.2. Training costs</b>						
Note: the time to attend a course should be included in						
No.	Profession	Number of	Cost per	Summary costs	Source of	Total
1	Acute urgent care course	20	£250			£5,000
2	Prescribing course	3	£310			£930
<b>Total</b>						<b>£5,930</b>
<b>A.3. Transport costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Travel and subsistence			£37,918	Business	£37,918
<b>Total</b>						<b>£37,918</b>
<b>A.4. Information and communication costs (e.g. brochures and leaflets for patients and their</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1						£0
<b>Total</b>						<b>£0</b>
<b>A.5. Clinical materials/equipment and</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Instruments and sundries			£2,867	Business	£2,867

2	Equipment repairs clinical			£585	Business	£585
3	Surgical appliances			£104	Business	£104
4	Drugs			£1,693	Business	£1,693
5	Equipment purchase clinical			£298	Business	£298
<b>Total</b>						<b>£5,546</b>
<b>A.6. Support services supplies</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Catering			£177	Business	£177
2	Uniforms			£552	Business	£552
3	Printing and stationery			£737	Business	£737
4	Dressings			£473	Business	£473
5	general services			£16	Business	£16
<b>Total</b>						<b>£1,955</b>
<b>A.7. Labs and diagnostics</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Diagnostic supplies			£559	Business	£559
<b>Total</b>						<b>£559</b>
<b>A.8. Overhead costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Telephone			£3,794	Business	£3,794
2	Building			£119	Business	£119
3	Miscellaneous			£34	Business	£34
<b>Total</b>						<b>£3,947</b>
<b>A.9. Other costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Equipment purchase non medical			£3,354	Business	£3,354
2	postage			£772	Business	£772
<b>Total</b>						<b>£4,126</b>
<b>A.10. Additional costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1						£0
<b>Total</b>						<b>£0</b>
<b>TOTAL</b>						<b>£1,112,79</b>
<b>Unit cost of HAH admission</b>						<b>£628.34</b>
<b>Unit cost of HAH bed day</b>						<b>£113.44</b>

<b>Site two</b>				<b>PERIOD</b>		
	<b>from:</b>	01/01/2015		<b>Until:</b>	01/01/2017	<b>24</b>
		(dd/mm/yyyy)			(dd/mm/yyyy)	Months
				Source of		
<b>Number of HAH admissions (in period)</b>	1547			ISD IPD data		
<b>Length of HAH stay per episode (in</b>	7.35	Mean		ISD IPD data		
	0.14	Standard error				
<b>HAH bed days (period)</b>	11376					

<b>A.1. Staff costs</b>							
No	Profession	WTEs	Gross	Summary salary	Source of	<b>Total</b>	
<b>a) Medical staff</b>							
1	Senior medical			£82,099	Business	£82,099	
2	Professional fees and charges			£124,391	Business	£124,391	
<b>b) Nursing and pharmacy services</b>							
1	Nursing & Midwifery-trained			£2,904,576	Business	£2,904,576	
2	Nursing & Midwifery-untrained			£627,532	Business	£627,532	
3	Pharmacists			£43,715	Business	£43,715	
4	Pharmacy Technicians			£14,471	Business	£14,471	
<b>c) Allied health professions</b>							
1					Business	£0	
<b>d) Administration, ICT and management</b>							
1	Admin Clerical			£126,018	Business	£126,018	
<b>e) Support services staff</b>							
1						£0	
<b>Total</b>						<b>£3,922,80</b>	
<b>A.2. Training costs</b>							
Note: the time to attend a course should be included in							
No.	Profession	Number of	Cost per	Summary costs	Source of	<b>Total</b>	
1	Training costs			£1,512		£1,512	
<b>Total</b>						<b>£1,512</b>	
<b>A.3. Transport costs</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of	<b>Total</b>	
1	Transport			£25,711	Business	£25,711	
2	Travel And Subsistence			£340,388		£340,388	
<b>Total</b>						<b>£366,099</b>	
<b>A.4. Information and communication costs (e.g. brochures and leaflets for patients and their</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of	<b>Total</b>	
1						£0	
<b>Total</b>						<b>£0</b>	
<b>A.5. Clinical materials/equipment and</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of	<b>Total</b>	
1	Drugs			£203,900	Business	£203,900	
2	Equipment			£14,589	Business	£14,589	
3	Paramedical Supplies			£3,015	Business	£3,015	
4	Surgical Appliances			£18	Business	£18	
5	Surgical Sundries			£80,855	Business	£80,855	
<b>Total</b>						<b>£302,377</b>	
<b>A.6. Support services supplies</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of	<b>Total</b>	
1	Bedding And Linen			£112	Business	£112	
2	Cleaning			£8,251	Business	£8,251	
3	General Services			£2,595		£2,595	
<b>Total</b>						<b>£10,958</b>	
<b>A.7. Labs and diagnostics</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of	<b>Total</b>	
1	Cssd/diagnostic Supplies			£3,783		£3,783	

							£3,783
<b>A.8. Overhead costs</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of		<b>Total</b>
1	Post Carriage And Telephones			£5,224			£5,224
2	Printing And Stationery			£5,737	Business		£5,737
3	Property Maintenance			£1,174			£1,174
4	Miscellaneous			£25	Business		£25
<b>Total</b>							<b>£12,160</b>
<b>A.9. Other costs</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of		<b>Total</b>
1	Provisions			£6	Business		£6
2	Uniforms			£334	Business		£334
<b>Total</b>							<b>£340</b>
<b>A.10. Additional costs</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of		<b>Total</b>
1	Other Operating Income**			-£92,377			-£92,377
<b>Total</b>							<b>-£92,377</b>
						<b>TOTAL</b>	<b>£4,527,65</b>
						<b>Unit cost of HAH admission</b>	<b>£2,926.73</b>
						<b>Unit cost of HAH bed day</b>	<b>£398.01</b>

**Site three**

	from:	<input type="text" value="01/01/2015"/> (dd/mm/yyyy)	PERIOD Until:	<input type="text" value="01/01/2016"/> (dd/mm/yyyy)	12 Months
Number of HAH admissions (in period)	<input type="text" value="598"/> 598		Source	of	<input type="text" value="ISD IPD data"/> business case
Length of HAH stay per episode (in days)	<input type="text" value="7.35"/> <input type="text" value="0.14"/>	Mean Standard error			<input type="text" value="ISD IPD data"/>
HAH bed days (period)	<input type="text" value="4397"/>				

A.1. Staff costs							
No.	Profession	WTEs	Gross annual	Summary salary cost	Source	of	Total
<b>a) Medical staff</b>							
1	Consultant	1		£114,776	Business		£114,77
2	Specialty doctor	1		£79,224	Business		£79,224
3					Business		£0
4							£0
5							£0
<b>b) Nursing and pharmacy services</b>							
1	Nurse (Band 6)	3		£125,484	Business		£125,48
2	Nurse (Band 5)	1.6		£53,256	Business		£53,256
<b>c) Allied health professions</b>							
1	Occupational therapist	1		£45,156	Business		£45,156
2	Physiotherapist	1		£45,156	Business		£45,156
<b>d) Administration, ICT and management</b>							
1	Admin Clerical	1		£23,664	Business		£23,664
<b>e) Support services staff</b>							
1							£0
<b>Total</b>							<b>£486,71</b>
A.2. Training costs							
Note: the time to attend a course should be included in							
No.	Profession	Number of	Cost per	Summary costs	Source	of	Total
1	Training costs			£1,000			£1,000
<b>Total</b>							<b>£1,000</b>
A.3. Transport costs							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1	Transport/travel			£20,000	Business		£20,000
<b>Total</b>							<b>£20,000</b>
A.4. Information and communication costs (e.g. brochures and leaflets for patients and their family)							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1							£0
<b>Total</b>							<b>£0</b>
A.5. Clinical materials/equipment and drugs							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1	Drugs			£4,840	Business		£4,840
2	Medical supplies			£2,393	Business		£2,393
<b>Total</b>							<b>£7,233</b>
A.6. Support services supplies							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1							£0
<b>Total</b>							<b>£0</b>
A.7. Labs and diagnostics							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1							£0
<b>Total</b>							<b>£0</b>
A.8. Overhead costs							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1	Phones, stationary etc.			£1,796	Business		£1,796
Total							£1,796
A.9. Other costs							
No.	Cost item	Number	of	Cost per item	Summary costs	Source	of Total
1	Mischellaneous				£250		£250
Total							£250
A.10 Additional costs							
No.	Cost item	Number	of	Cost per item	Summary costs	Source	of Total
1							£0
Total							£0

TOTAL £516,99

Unit cost of HAH admission £864.54

Unit cost of HAH bed day £117.57

or peer review only

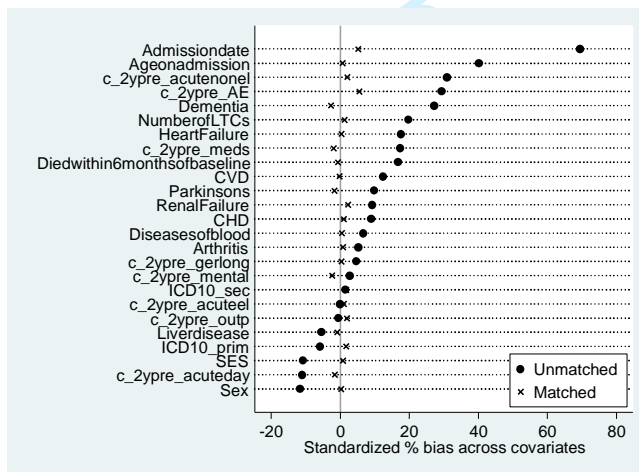


Appendix 2 Results of selecting PSM technique and plots of covariance balance before and after propensity score matching

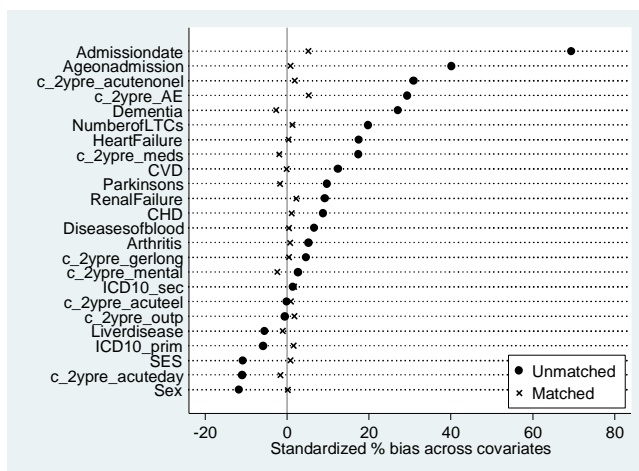
Variable	Site one		Site two		Site three	
	Costs	Survival	Costs	Survival	Costs	Survival
	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R
Mahalanobis	7.5/4.2;51.4/1.56	7.2/3.7;48.6/1.54	7.6/6.7;46.1/1.54	7.3/6.7;43.9/1.53	6.3/4.7/38.4/1.69	6.3/3.5/38.4/1.52
1-to-1	2.9/2.8;14.1/0.90	1.9/1.6;12.1/0.84	1.4/1.4;9.4/0.97	2.2/2.2;14.6/1.14	2.7/2.7/14.6/1.02	2.3/2.6/14.9/0.73
K-to-1	1.9/1.6;11.3/0.76	1.9/1.5;12.0/0.81	1.8/1.5;11.0/0.83	2.4/2.4;13.6/0.76	3.6/2.9/16.5/0.99	2.8/2.0/16.5/0.94
Kernel	1.6/1.1;9.8/0.97	1.5/1.2;8.9/0.92	1.1/0.9;6.9/1.02	0.9/0.7;6.5/1.01	2.2/1.6/12.3/1.22	1.9/1.2/11.2/1.21
Local linear regression	1.5/1.2;9.4/0.89	1.6/1.4;9.4/0.89	1.7/1.0;11.0/0.32	2.3/1.4;12.8/0.43	1.8/1.6/9.6/1.27	1.6/1.2/8.5/1.35
Spline	2.9/2.6;15.7/0.94	2.4/2.0;14.9/0.91	3.2/2.6;17.5/0.46	3.2/2.3;21.0/1.07	3.9/3.1/21.6/0.47	3.9/2.3/25.7/1.02
IPW	11.5/5.8;83.2/0.76	11.5/5.6;83.1/0.75	11.6/8.3;61.3/0.92	11.2/7.8;60.2/0.89	10.5/8.5/52.2/0.77	10.2/8.5/50.9/0.77

Rubin's B: the absolute standardized difference of the means of the linear index of the propensity score in the treated and (matched) non-treated group; Rubin's R: the ratio of treated to (matched) non-treated variances of the propensity score index; Samples sufficiently balanced if B less than 25 and that R between 0.5 and 2.

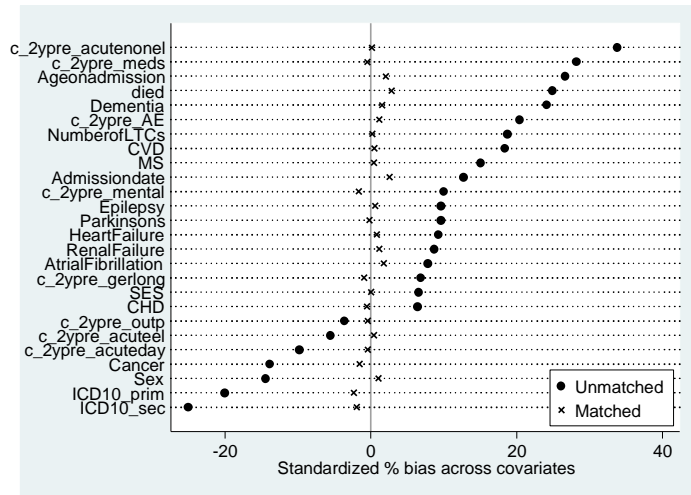
Standardised percentage bias before and after local linear regression propensity score matching for costs in site one



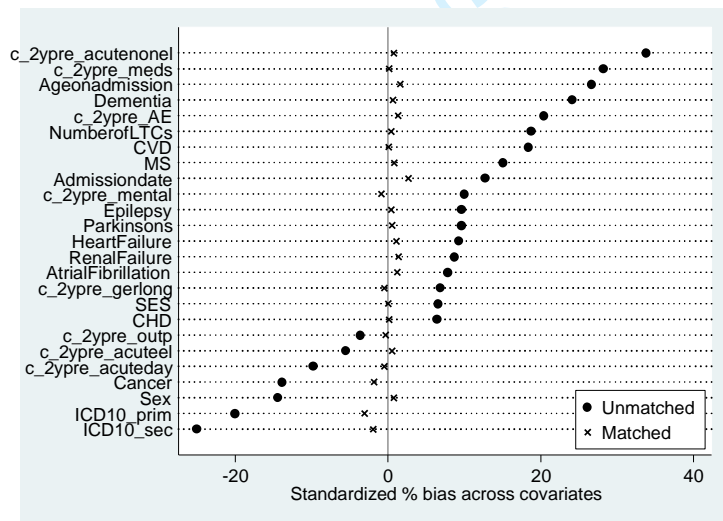
Standardised percentage bias before and after local linear regression propensity score matching for survival in site one



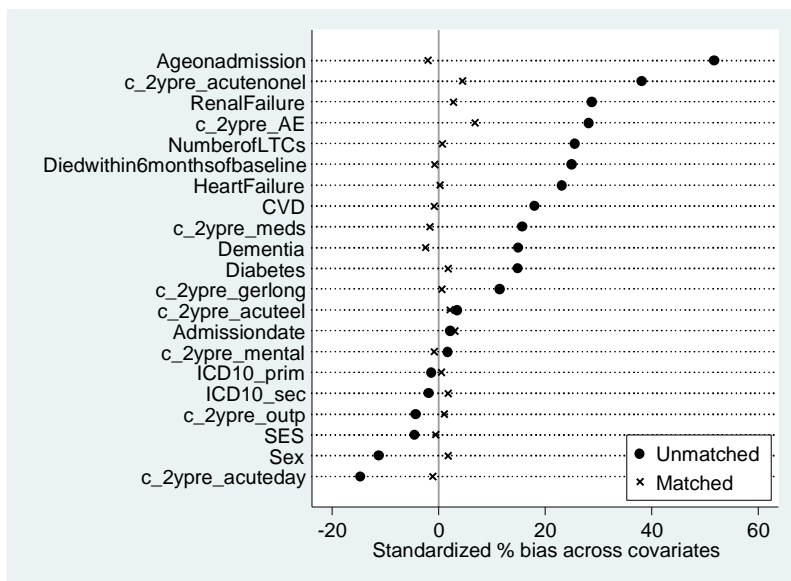
Standardised percentage bias before and after Kernel propensity score matching for costs in site two



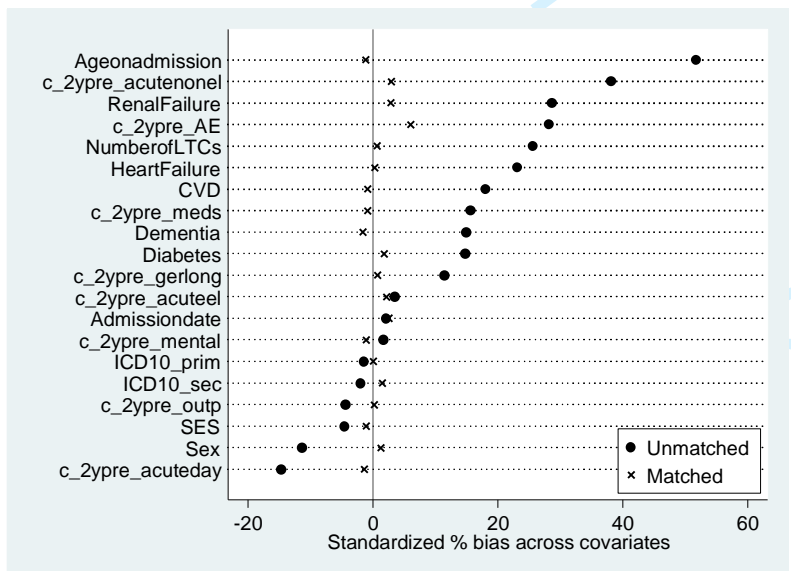
Standardised percentage bias before and after Kernel propensity score matching for survival in site two



Standardised percentage bias before and after local linear regression propensity score matching for costs in site three

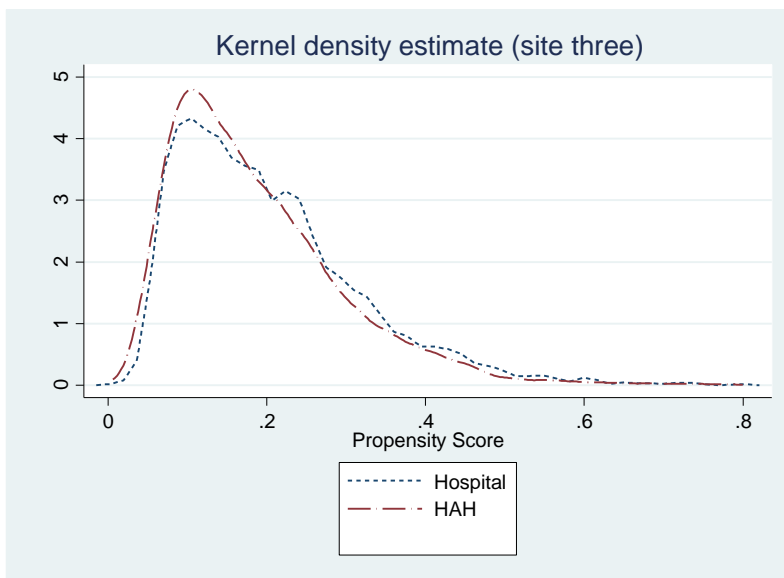
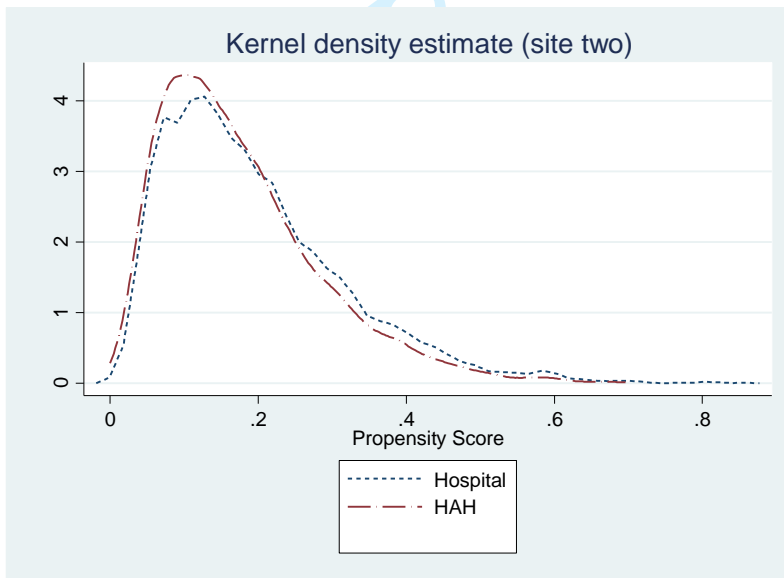
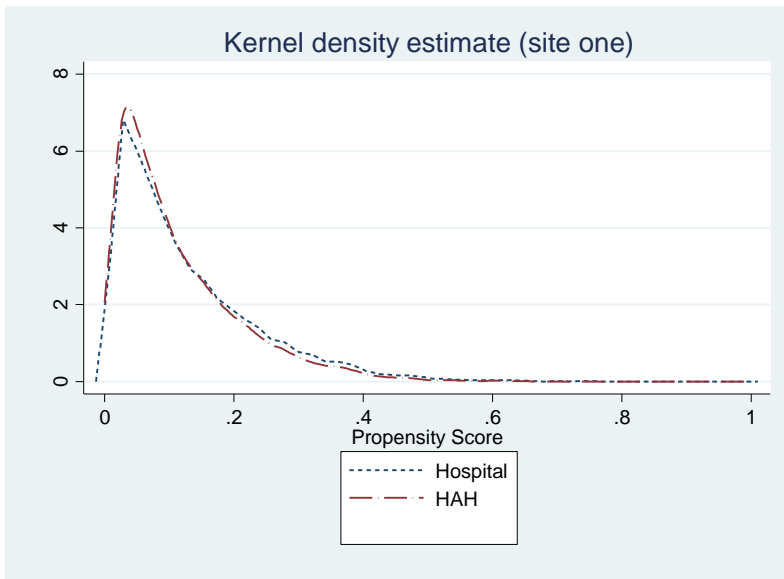


Standardised percentage bias before and after local linear regression propensity score matching for survival in site three



1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

Propensity score distributions by cohort in each site



## Patient characteristics at index admission after propensity score matching

Variable	Site one		Site two		Site three	
	Control	HAH	Control	HAH	Control	HAH
Mean age on admission (sd)	81.2 (7.95)	81.2 (7.20)	82.2 (8.03)	82.4 (7.68)	81.6 (7.96)	81.4 (7.10)
Female	63%	63%	62%	62%	62%	61%
Higher than 4 on the SIMD	35%	35%	53%	52%	44%	44%
More than 4 chronic conditions	44%	45%	48%	50%	43%	43%
Arthritis	29%	29%	38%	38%	33%	36%
Asthma	10%	11%	13%	14%	9%	11%
Atrial fibrillation	29%	28%	32%	33%	30%	29%
Cancer	28%	28%	28%	27%	30%	28%
CVD	27%	27%	26%	26%	27%	26%
Liver disease	3%	3%	4%	4%	4%	5%
COPD	27%	29%	26%	28%	26%	30%
Dementia	26%	25%	26%	26%	18%	17%
Diabetes	23%	23%	23%	24%	26%	26%
Epilepsy	4%	4%	5%	5%	2%	2%
CHD	42%	42%	40%	40%	37%	32%
Heart failure	23%	23%	22%	23%	25%	25%
MS	0%	0%	1%	1%	1%	1%
Parkinson's	4%	4%	3%	3%	3%	5%
Renal failure	22%	23%	24%	24%	25%	25%
Congenital problems	2%	2%	4%	4%	2%	2%
Diseases of blood	32%	32%	30%	27%	29%	29%
Endocrine metabolic disease	36%	36%	46%	45%	39%	35%
Disease of digestive system	70%	72%	70%	70%	64%	66%

HAH: hospital-at-home; SIMD ranges from 1 (most deprived) to 10 (most affluent); Note: a patient could be registered with more than one ICD-10 codes

Appendix 3. Full results of the regression analyses

Association of hospital at home with total costs (after propensity score matching)

	site one (n=13,267)		site two (n=4,769)		site three (n=2110)	
	Follow-up period coefficient (se) [95%CI] p value	6 months after discharge coefficient (se) [95%CI] p value	Follow-up period coefficient (se) [95%CI] p value	6 months after discharge coefficient (se) [95%CI] p value	Follow-up period coefficient (se) [95%CI] p value	6 months after discharge coefficient (se) [95%CI] p value
HAH	0.82 (0.03) [0.76;0.89] <0.001	1.27 (0.07) [1.14;1.41] <0.001	1.00 (0.05) [0.92;1.09] 0.982	1.09 (0.07) [0.95;1.24] 0.219	1.15 (0.09) [0.99;1.33] 0.073	1.70 (0.17) [1.4;2.07] <0.001
Admission date	1.00 (0.00) [1.00;1.00] 0.058	1.00 (0.00) [1.00;1.00] 0.009	1.00 (0.00) [1.00;1.00] 0.386	1.00 (0.00) [1.00;1.00] 0.824	1.00 (0.00) [1.00;1.00] 0.009	1.00 (0.00) [1.00;1.00] 0.056
ICD10 primary	1.00 (0.00) [1.00;1.00] 0.660	1.00 (0.00) [1.00;1.00] 0.230	1.00 (0.00) [1.00;1.00] 0.001	1.00 (0.00) [1.00;1.00] <0.001	1.00 (0.00) [1.00;1.00] 0.162	1.00 (0.00) [1.00;1.00] 0.101
ICD10 secondary	1.00 (0.00) [1.00;1.00] 0.641	1.00 (0.00) [1.00;1.00] 0.988	1.00 (0.00) [1.00;1.00] 0.146	1.00 (0.00) [1.00;1.00] 0.238	1.00 (0.00) [1.00;1.00] 0.897	1.00 (0.00) [1.00;1.00] 0.971
2yrs pre AE costs	1.00 (0.00) [1.00;1.00] 0.240	1.00 (0.00) [1.00;1.00] 0.018	1.00 (0.00) [1.00;1.00] 0.624	1.00 (0.00) [1.00;1.00] 0.309	1.00 (0.00) [1.00;1.00] 0.284	1.00 (0.00) [1.00;1.00] 0.42
2yrs pre elective costs	1.00 (0.00) [1.00;1.00] 0.906	1.00 (0.00) [1.00;1.00] 0.919	1.00 (0.00) [1.00;1.00] 0.588	1.00 (0.00) [1.00;1.00] 0.435	1.00 (0.00) [1.00;1.00] 0.865	1.00 (0.00) [1.00;1.00] 0.931
2yrs pre non-elective costs	1.00 (0.00) [1.00;1.00] <0.001	1.00 (0.00) [1.00;1.00] 0.001	1.00 (0.00) [1.00;1.00] 0.694	1.00 (0.00) [1.00;1.00] 0.697	1.00 (0.00) [1.00;1.00] 0.018	1.00 (0.00) [1.00;1.00] 0.015
2yrs pre day case costs	1.00 (0.00) [1.00;1.00] 0.098	1.00 (0.00) [1.00;1.00] 0.020	1.00 (0.00) [1.00;1.00] 0.005	1.00 (0.00) [1.00;1.00] <0.001	1.00 (0.00) [1.00;1.00] 0.14	1.00 (0.00) [1.00;1.00] 0.100
2yrs pre geriatric ward costs	1.00 (0.00) [1.00;1.00] 0.005	1.00 (0.00) [1.00;1.00] 0.054	1.00 (0.00) [1.00;1.00] 0.001	1.00 (0.00) [1.00;1.00] 0.003	1.00 (0.00) [1.00;1.00] 0.634	1.00 (0.00) [1.00;1.00] 0.342
2yrs pre mental ward costs	1.00 (0.00) [1.00;1.00] 0.880	1.00 (0.00) [1.00;1.00] 0.911	1.00 (0.00) [1.00;1.00] 0.009	1.00 (0.00) [1.00;1.00] 0.014	1.00 (0.00) [1.00;1.00] 0.111	1.00 (0.00) [1.00;1.00] 0.382
2yrs pre outpatient costs	1.00 (0.00) [1.00;1.00] 0.087	1.00 (0.00) [1.00;1.00] 0.056	1.00 (0.00) [1.00;1.00] 0.026	1.00 (0.00) [1.00;1.00] 0.043	1.00 (0.00) [1.00;1.00] 0.683	1.00 (0.00) [1.00;1.00] 0.656
2yrs pre medication costs	1.00 (0.00) [1.00;1.00] 0.798	1.00 (0.00) [1.00;1.00] 0.750	1.00 (0.00) [1.00;1.00] 0.172	1.00 (0.00) [1.00;1.00] 0.369	1.00 (0.00) [1.00;1.00] 0.687	1.00 (0.00) [1.00;1.00] 0.935
Died during follow-up	1.03 (0.04) [0.95;1.11] 0.530	0.91 (0.05) [0.82;1.01] 0.089	1.05 (0.05) [0.96;1.15] 0.302	0.90 (0.06) [0.78;1.05] 0.143	1.06 (0.09) [0.90;1.24] 0.498	0.97 (0.11) [0.78;1.21] 0.784
Number of LTCs	1.09 (0.02) [1.05;1.12] <0.001	1.12 (0.02) [1.07;1.16] <0.001	1.04 (0.02) [1.00;1.07] 0.054	1.06 (0.03) [1.00;1.11] 0.035	1.06 (0.03) [1.01;1.11] 0.017	1.10 (0.03) [1.03;1.17] 0.003
Age on admission	1.00 (0.00) [0.99;1.01] 0.383	1.00 (0.00) [0.99;1.01] 0.981	1.00 (0.00) [0.99;1.01] 0.984	1.00 (0.00) [1.00;1.00] 0.349	1.01 (0.01) [1.00;1.02] 0.045	1.01 (0.01) [0.99;1.02] 0.41
Male	1.09 (0.05) [1.01;1.19] 0.034	1.08 (0.06) [0.97;1.19] 0.136	0.95 (0.05) [0.86;1.05] 0.340	0.99 (0.08) [0.85;1.15] 0.859	0.97 (0.08) [0.83;1.13] 0.709	0.98 (0.10) [0.81;1.2] 0.875
SES	1.00 (0.01) [0.98;1.02] 0.988	1.00 (0.01) [0.98;1.03] 0.741	1.01 (0.01) [1.00;1.03] 0.182	1.03 (0.01) [1.00;1.05] 0.033	1.00 (0.02) [0.97;1.03] 0.899	1.01 (0.02) [0.97;1.05] 0.779
Arthritis	0.96 (0.04) [0.88;1.05] 0.398	0.95 (0.05) [0.85;1.06] 0.346	-----	-----	-----	-----
Atrial Fibrillation	-----	-----	1.09 (0.06) [0.98;1.2] 0.098	1.13 (0.08) [0.97;1.30] 0.113	-----	-----
Cancer	-----	-----	1.04 (0.05) [0.94;1.15] 0.485	1.07 (0.08) [0.92;1.24] 0.403	-----	-----
CVD	1.01 (0.06) [0.91;1.13] 0.767	0.99 (0.07) [0.86;1.13] 0.903	1.08 (0.06) [0.97;1.2] 0.168	1.11 (0.09) [0.95;1.29] 0.199	1.10 (0.11) [0.90;1.34] 0.339	1.07 (0.13) [0.84;1.37] 0.585
Liver disease	1.21 (0.13) [0.98;1.50] 0.074	1.20 (0.14) [0.95;1.51] 0.130	-----	-----	-----	-----
Dementia	1.06 (0.05) [0.97;1.17] 0.179	1.07 (0.07) [0.95;1.21] 0.236	1.00 (0.05) [0.91;1.11] 0.942	1.03 (0.08) [0.89;1.19] 0.683	1.14 (0.11) [0.95;1.38] 0.166	1.17 (0.15) [0.91;1.5] 0.211
Epilepsy	-----	-----	1.04 (0.11) [0.85;1.27] 0.734	1.04 (0.15) [0.78;1.38] 0.803	-----	-----
CHD	0.85 (0.05) [0.77;0.95] 0.004	0.83 (0.06) [0.73;0.95] 0.008	1.01 (0.06) [0.9;1.13] 0.871	1.02 (0.08) [0.88;1.20] 0.766	-----	-----
Heart Failure	1.09 (0.06) [0.98;1.20] 0.102	1.10 (0.07) [0.97;1.24] 0.154	1.08 (0.06) [0.96;1.21] 0.186	1.08 (0.09) [0.92;1.28] 0.363	1.01 (0.10) [0.83;1.23] 0.919	0.98 (0.13) [0.76;1.26] 0.879
Multiple sclerosis	-----	-----	0.74 (0.10) [0.57;0.98] 0.033	0.59 (0.15) [0.36;0.97] 0.035	-----	-----
Parkinson's	1.24 (0.11) [1.03;1.48] 0.019	1.20 (0.14) [0.95;1.51] 0.120	1.09 (0.15) [0.83;1.42] 0.554	1.09 (0.20) [0.75;1.57] 0.664	-----	-----
Renal Failure	1.03 (0.05) [0.94;1.13] 0.513	1.06 (0.06) [0.94;1.19] 0.362	1.05 (0.06) [0.94;1.17] 0.420	1.08 (0.09) [0.92;1.26] 0.348	1.12 (0.12) [0.9;1.38] 0.306	1.14 (0.16) [0.87;1.49] 0.346
Diseases of blood	1.05 (0.05) [0.96;1.15] 0.275	1.05 (0.06) [0.94;1.18] 0.363	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	1.21 (0.11) [1.01;1.45] 0.043	1.24 (0.14) [0.99;1.55] 0.061
Constant	15.93 (46.90) [0.05;5098.92] 0.347	0.19 (0.68) [0.00;224.04] 0.644	285486.5 (1267507) [47.47; 1.72E+09] 0.005	899.53 (5743.23) [0.00;0.00] 0.287	2070000000000 (186000000000000) [500612.1;8.6E+20] 0.001	2230000000000 (25100000000000) [559.85;8.85E+21] 0.012

# driven mainly by non-elective hospital care; Note the HAH unit costs in site one were £628.34 per admission to HAH and have been added to the costs during the episode.

## Association of hospital-at-home with mortality risk during study period (after propensity score matching)

	site one (n=13,267)				site two (n=4,771)				site three (n=2110)			
	coefficient	(se)	[95%CI]	p value	coefficient	(se)	[95%CI]	p value	coefficient	(se)	[95%CI]	p value
HAH	1.09	(0.05)	[1.00;1.19]	0.059	1.29	(0.07)	[1.15;1.44]	<0.0010	1.27	(0.12)	[1.06;1.54]	0.011
Admission date	1.00	(0.00)	[1.00;1.00]	0.842	1.00	(0.00)	[1.00;1.00]	0.100	1	(0)	[1;1]	0.687
ICD10 primary	1.00	(0.00)	[1.00;1.00]	<0.001	1.00	(0.00)	[1.00;1.00]	0.001	1	(0)	[1;1]	0.006
ICD10 secondary	1.00	(0.00)	[1.00;1.00]	<0.001	1.00	(0.00)	[1.00;1.00]	0.023	1	(0)	[1;1]	0.359
2yrs pre AE costs	1.00	(0.00)	[1.00;1.00]	0.640	1.00	(0.00)	[1.00;1.00]	0.153	1	(0)	[1;1]	0.027
2yrs pre elective costs	1.00	(0.00)	[1.00;1.00]	0.487	1.00	(0.00)	[1.00;1.00]	0.462	1	(0)	[1;1]	0.079
2yrs pre non-elective costs	1.00	(0.00)	[1.00;1.00]	0.001	1.00	(0.00)	[1.00;1.00]	0.007	1	(0)	[1;1]	0.052
2yrs pre day case costs	1.00	(0.00)	[1.00;1.00]	<0.001	1.00	(0.00)	[1.00;1.00]	0.001	1	(0)	[1;1]	0.903
2yrs pre geriatric ward costs	1.00	(0.00)	[1.00;1.00]	0.022	1.00	(0.00)	[1.00;1.00]	<0.001	1	(0)	[1;1]	0.338
2yrs pre mental ward costs	1.00	(0.00)	[1.00;1.00]	0.419	1.00	(0.00)	[1.00;1.00]	0.943	1	(0)	[1;1]	0
2yrs pre outpatient costs	1.00	(0.00)	[1.00;1.00]	0.091	1.00	(0.00)	[1.00;1.00]	0.882	1	(0)	[1;1]	0.001
2yrs pre medication costs	1.00	(0.00)	[1.00;1.00]	0.044	1.00	(0.00)	[1.00;1.00]	0.037	1	(0)	[1;1]	0
Number of LTCs	1.03	(0.02)	[0.99;1.07]	0.120	0.96	(0.02)	[0.92;1.01]	0.107	1.07	(0.04)	[1;1.14]	0.048
Age on admission	1.04	(0)	[1.03;1.04]	<0.001	1.03	(0.00)	[1.02;1.04]	<0.001	1.04	(0.01)	[1.02;1.05]	0
Male	1.12	(0.05)	[1.01;1.22]	0.017	1.23	(0.08)	[1.09;1.39]	0.001	1.37	(0.14)	[1.12;1.67]	0.002
SES	0.97	(0.01)	[0.95;0.99]	0.001	0.98	(0.01)	[0.96;1.00]	0.088	1.01	(0.02)	[0.98;1.05]	0.483
Arthritis	0.86	(0.05)	[0.77;0.97]	0.008	-----	-----	-----	-----	-----	-----	-----	-----
Atrial Fibrillation	-----	-----	-----	-----	1.11	(0.08)	[0.97;1.28]	0.133	-----	-----	-----	-----
Cancer	-----	-----	-----	-----	1.86	(0.12)	[1.64;2.11]	<0.001	-----	-----	-----	-----
CVD	0.94	(0.06)	[0.83;1.05]	0.276	1.06	(0.08)	[0.92;1.22]	0.438	0.95	(0.12)	[0.74;1.21]	0.673
Liver disease	1.33	(0.16)	[1.04;1.67]	0.015	-----	-----	-----	-----	-----	-----	-----	-----
Dementia	1.11	(0.06)	[1.00;1.25]	0.058	1.59	(0.11)	[1.39;1.82]	<0.001	1.31	(0.16)	[1.03;1.67]	0.025
Epilepsy	-----	-----	-----	-----	1.19	(0.17)	[0.91;1.57]	0.207	-----	-----	-----	-----
CHD	0.91	(0.05)	[0.82;1.03]	0.114	0.93	(0.07)	[0.80;1.08]	0.345	-----	-----	-----	-----
Heart Failure	1.13	(0.07)	[1.00;1.28]	0.052	1.35	(0.11)	[1.15;1.57]	<0.001	1.16	(0.15)	[0.9;1.5]	0.256
Multiple sclerosis	-----	-----	-----	-----	1.54	(0.39)	[0.94;2.52]	0.086	-----	-----	-----	-----
Parkinson's	1.11	(0.13)	[0.86;1.39]	0.374	0.93	(0.17)	[0.65;1.33]	0.678	-----	-----	-----	-----
Renal Failure	1.07	(0.07)	[0.95;1.21]	0.292	1.35	(0.10)	[1.16;1.56]	<0.001	0.93	(0.12)	[0.72;1.2]	0.571
Diseases of blood	0.93	(0.05)	[0.85;1.06]	0.201	-----	-----	-----	-----	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	-----	-----	-----	-----	0.74	(0.1)	[0.57;0.97]	0.026
Constant	0.01	(0.04)	[0.00;7.06]	0.174	0.00	(0.00)	[0.00;0.18]	0.025	0	(0)	[0;319640.8]	0.405

## Results of the subgroup analysis including only patients with dementia (costs)

	site one (n=2,321)		site two (n=1,053)		site three (n=280)	
	Follow-up period	Total costs in 6 months after discharge	Follow-up period	Total costs in 6 months after discharge	Follow-up period	Total costs in 6 months after discharge
	coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value
HAH (hospital)	0.76 (0.05) [0.66;0.87] 0	1.18 (0.11) [0.99;1.41] 0.071	0.76 (0.06) [0.66;0.88] 0	0.75 (0.09) [0.59;0.96] 0.021	0.87 (0.15) [0.63;1.21] 0.409	1.58 (0.41) [0.95;2.63] 0.078
Admission date	1 (0) [1;1] 0.528	1.00 (0.00) [1.00;1.00] 0.329	1 (0) [1;1] 0.513	1.00 (0.00) [1.00;1.00] 0.532	1 (0) [1;1] 0.002	1 (0) [0.99;1] 0.003
ICD10 primary	1 (0) [1;1] 0.025	1.00 (0.00) [1.00;1.00] 0.003	1 (0) [1;1] 0.079	1.00 (0.00) [1.00;1.00] 0.008	1 (0) [1;1] 0.666	1 (0) [1;1] 0.123
ICD10 secondary	1 (0) [1;1] 0.027	1.00 (0.00) [1.00;1.00] 0.086	-----	-----	1 (0) [1;1] 0.946	1 (0) [1;1] 0.594
2yrs pre AE costs	1 (0) [1;1] 0.063	1.00 (0.00) [1.00;1.00] 0.021	1 (0) [1;1] 0.979	1.00 (0.00) [1.00;1.00] 0.93	1 (0) [1;1] 0.57	1 (0) [1;1] 0.331
2yrs pre elective costs	1 (0) [1;1] 0.913	1.00 (0.00) [1.00;1.00] 0.708	1 (0) [1;1] 0.979	1.00 (0.00) [1.00;1.00] 0.889	1 (0) [1;1] 0.115	1 (0) [1;1] 0.208
2yrs pre non-elective costs	1 (0) [1;1] 0.564	1.00 (0.00) [1.00;1.00] 0.605	1 (0) [1;1] 0.031	1.00 (0.00) [1.00;1.00] 0.008	1 (0) [1;1] 0.888	1 (0) [1;1] 0.639
2yrs pre day case costs	1 (0) [1;1] 0.455	1.00 (0.00) [1.00;1.00] 0.632	1 (0) [1;1] 0.725	1.00 (0.00) [1.00;1.00] 0.307	1 (0) [1;1] 0.1	1 (0) [1;1] 0.279
2yrs pre geriatric ward costs	1 (0) [1;1] 0.233	1.00 (0.00) [1.00;1.00] 0.566	1 (0) [1;1] 0.012	1.00 (0.00) [1.00;1.00] 0.003	1 (0) [1;1] 0.907	1 (0) [1;1] 0.952
2yrs pre mental ward costs	1 (0) [1;1] 0.343	1.00 (0.00) [1.00;1.00] 0.335	1 (0) [1;1] 0.084	1.00 (0.00) [1.00;1.00] 0.042	1 (0) [1;1] 0.01	1 (0) [1;1] 0.021
2yrs pre outpatient costs	1 (0) [1;1] 0.066	1.00 (0.00) [1.00;1.00] 0.082	1 (0) [1;1] 0.001	1.00 (0.00) [1.00;1.00] 0.001	1 (0) [1;1] 0.685	1 (0) [1;1] 0.403
2yrs pre medication costs	1 (0) [1;1] 0.306	1.00 (0.00) [1.00;1.00] 0.316	1 (0) [1;1] 0.13	1.00 (0.00) [1.00;1.00] 0.265	1 (0) [1;1] 0.042	1 (0) [1;1] 0.044
Died within 6months	0.81 (0.06) [0.7;0.94] 0.005	0.70 (0.07) [0.58;0.85] <0.001	0.89 (0.07) [0.76;1.03] 0.118	0.73 (0.09) [0.58;0.93] 0.011	0.66 (0.13) [0.45;0.96] 0.031	0.44 (0.13) [0.25;0.77] 0.004
Number of LTCs	1.06 (0.03) [1;1.12] 0.069	1.07 (0.04) [1.00;1.16] 0.063	1.08 (0.03) [1.02;1.14] 0.006	1.15 (0.05) [1.05;1.26] 0.003	1.04 (0.06) [0.94;1.16] 0.443	1.01 (0.08) [0.86;1.18] 0.935
Age on admission	0.99 (0.01) [0.98;1] 0.094	0.98 (0.01) [0.97;1.00] 0.015	0.98 (0.01) [0.97;1] 0.007	0.97 (0.01) [0.95;0.99] 0.003	1 (0.01) [0.98;1.03] 0.933	1 (0.02) [0.97;1.03] 0.946
Male	1.13 (0.08) [0.99;1.31] 0.076	1.14 (0.11) [0.95;1.37] 0.151	0.95 (0.07) [0.82;1.11] 0.511	0.95 (0.12) [0.74;1.22] 0.679	1.05 (0.17) [0.76;1.43] 0.78	1.07 (0.26) [0.67;1.71] 0.774
SES	1.01 (0.01) [0.98;1.04] 0.693	1.01 (0.02) [0.97;1.04] 0.77	1.03 (0.01) [1;1.05] 0.053	1.06 (0.02) [1.01;1.10] 0.010	1.03 (0.03) [0.97;1.09] 0.3	1.04 (0.04) [0.96;1.12] 0.3
Atrial Fibrillation	-----	-----	1.03 (0.09) [0.87;1.23] 0.722	1.00 (0.14) [0.77;1.31] 0.986	-----	-----
Arthritis	1.02 (0.09) [0.86;1.2] 0.833	1.02 (0.11) [0.83;1.25] 0.862	-----	-----	-----	-----
Cancer	-----	-----	1.04 (0.1) [0.87;1.24] 0.679	1.06 (0.16) [0.79;1.43] 0.688	-----	-----
CVD	0.92 (0.07) [0.78;1.08] 0.3	0.91 (0.1) [0.74;1.12] 0.374	0.98 (0.08) [0.83;1.16] 0.845	0.95 (0.14) [0.72;1.26] 0.741	1.39 (0.28) [0.94;2.06] 0.103	1.65 (0.48) [0.93;2.91] 0.085
Liver disease	0.8 (0.12) [0.59;1.08] 0.138	0.8 (0.16) [0.54;1.20] 0.286	-----	-----	-----	-----
CHD	1.01 (0.09) [0.85;1.2] 0.917	1.05 (0.12) [0.84;1.30] 0.688	0.94 (0.09) [0.78;1.12] 0.482	0.98 (0.14) [0.74;1.30] 0.891	-----	-----
Epilepsy	-----	-----	0.97 (0.15) [0.72;1.3] 0.842	0.78 (0.16) [0.53;1.16] 0.221	-----	-----
Heart Failure	1.03 (0.11) [0.83;1.27] 0.818	1.02 (0.14) [0.79;1.33] 0.878	0.92 (0.11) [0.73;1.15] 0.452	0.90 (0.17) [0.62;1.29] 0.558	0.83 (0.19) [0.53;1.3] 0.409	1.16 (0.42) [0.57;2.37] 0.687
Multiple sclerosis	-----	-----	0.4 (0.06) [0.29;0.54] 0	0.18 (0.07) [0.09;0.37] <0.001	-----	-----
Parkinson's	1.13 (0.15) [0.88;1.46] 0.333	1.00 (0.17) [0.72;1.39] 0.992	0.87 (0.14) [0.63;1.18] 0.365	0.68 (0.20) [0.39;1.20] 0.188	-----	-----
Renal Failure	1.03 (0.1) [0.85;1.24] 0.769	1.12 (0.14) [0.88;1.42] 0.354	0.9 (0.09) [0.75;1.09] 0.296	0.82 (0.13) [0.60;1.12] 0.203	1.2 (0.24) [0.81;1.78] 0.354	1.25 (0.35) [0.72;2.17] 0.435
Diseases of blood	0.93 (0.08) [0.79;1.11] 0.437	0.90 (0.1) [0.73;1.11] 0.337	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	0.85 (0.18) [0.55;1.3] 0.449	0.92 (0.26) [0.52;1.6] 0.756
Constant	469.5 (2319.98) [0.03;7547051] 0.213	22.71 (140.52) [0;4194325] 0.614	2796754 (19900000) [2.38;3290000000000] 0.037	40500000 (472000000) [0;32900000000000000] 0.132	2.82E+29 (5.36E+30) [18000000000000;4.43E+45] 0	3.34E+38 (9.1E+39) [210000000000000;5.29E+61] 0.001



## Results of the subgroup analysis including only patients with dementia (mortality risk)

	site one (n=2,321)	site two (n=1,053)	site three (n=280)
	Mortality rate during follow-up coefficient (se) [95%CI] p value	Mortality rate during follow-up coefficient (se) [95%CI] p value	Mortality rate during follow-up coefficient (se) [95%CI] p value
HAH (hospital)	1.05 (0.09) [0.89;1.24] 0.594	1.41 (0.12) [1.19;1.67] <0.001	1.65 (0.32) [1.12;2.41] 0.011
Admission date	1.00 (0.00) [1.00;1.00] 0.19	1.00 (0.00) [1.00;1.00] 0.001	1 (0) [1;1] 0.788
ICD10 primary	1.00 (0.00) [1.00;1.00] <0.001	1.00 (0.00) [1.00;1.00] 0.001	1 (0) [1;1] 0.14
ICD10 secondary	1.00 (0.00) [1.00;1.00] 0.207	-----	1 (0) [1;1] 0.979
2yrs pre AE costs	1.00 (0.00) [1.00;1.00] 0.251	1.00 (0.00) [1.00;1.00] 0.609	1 (0) [1;1] 0.029
2yrs pre elective costs	1.00 (0.00) [1.00;1.00] 0.735	1.00 (0.00) [1.00;1.00] 0.129	1 (0) [1;1] 0.554
2yrs pre non-elective costs	1.00 (0.00) [1.00;1.00] 0.173	1.00 (0.00) [1.00;1.00] 0.484	1 (0) [1;1] 0.814
2yrs pre day case costs	1.00 (0.00) [1.00;1.00] 0.088	1.00 (0.00) [1.00;1.00] 0.004	1 (0) [1;1] 0.896
2yrs pre geriatric ward costs	1.00 (0.00) [1.00;1.00] 0.644	1.00 (0.00) [1.00;1.00] <0.001	1 (0) [1;1] 0.783
2yrs pre mental ward costs	1.00 (0.00) [1.00;1.00] 0.569	1.00 (0.00) [1.00;1.00] 0.112	1 (0) [1;1] 0
2yrs pre outpatient costs	1.00 (0.00) [1.00;1.00] 0.070	1.00 (0.00) [1.00;1.00] 0.167	1 (0) [1;1] 0
2yrs pre medication costs	1.00 (0.00) [1.00;1.00] 0.004	1.00 (0.00) [1.00;1.00] 0.156	1 (0) [1;1] 0.011
Died within 6months	-----	-----	-----
Number of LTCs	0.94 (0.03) [0.88;1.01] 0.113	0.95 (0.03) [0.89;1.01] 0.115	0.98 (0.07) [0.86;1.13] 0.827
Age on admission	1.04 (0.01) [1.02;1.05] <0.001	1.03 (0.01) [1.01;1.04] <0.001	1.04 (0.02) [1;1.07] 0.024
Male	1.19 (0.11) [0.99;1.42] 0.063	1.17 (0.10) [0.99;1.38] 0.070	1.18 (0.25) [0.78;1.79] 0.43
SES	0.97 (0.02) [0.94;1.01] 0.134	1.00 (0.02) [0.97;1.03] 0.991	0.96 (0.04) [0.88;1.04] 0.3
Atrial Fibrillation	-----	1.03 (0.11) [0.85;1.26] 0.75	-----
Arthritis	1.06 (0.11) [0.86;1.30] 0.600	-----	-----
Cancer	-----	1.40 (0.13) [1.16;1.68] <0.001	-----
CVD	1.55 (0.41) [0.92;2.61] 0.099	1.14 (0.11) [0.94;1.39] 0.176	1.02 (0.25) [0.63;1.65] 0.925
Liver disease	0.98 (0.11) [0.79;1.21] 0.845	-----	-----
CHD	1.21 (0.16) [0.94;1.56] 0.135	0.99 (0.10) [0.81;1.20] 0.885	-----
Epilepsy	-----	1.26 (0.19) [0.94;1.70] 0.120	-----
Heart Failure	1.21 (0.16) [0.94;1.56] 0.135	1.33 (0.17) [1.04;1.70] 0.023	1.88 (0.49) [1.12;3.14] 0.017
Multiple sclerosis	-----	0.96 (0.51) [0.34;2.72] 0.932	-----
Parkinson's	1.26 (0.22) [0.9;1.78] 0.180	1.04 (0.20) [0.71;1.51] 0.848	-----
Renal Failure	1.06 (0.12) [0.84;1.32] 0.637	1.15 (0.12) [0.93;1.41] 0.192	0.56 (0.16) [0.32;0.97] 0.037
Diseases of blood	0.96 (0.11) [0.77;1.19] 0.709	-----	-----
Diabetes	-----	-----	0.6 (0.2) [0.32;1.15] 0.123
Constant	0.00 (0.00) [0.00;1.37] 0.057	0.00 (0.00) [0.00;0.00] <0.001	0 (0) [0;1810000000000000] 0.652

## Results of the subgroup analysis excluding those who had died

	site one (n=10,132)		site two (n=3,584)		site three (n=1691)	
	Follow-up period coefficient (se) [95%CI] p value	Total costs in 6 months after discharge coefficient (se) [95%CI] p value	Follow-up period coefficient (se) [95%CI] p value	Total costs in 6 months after discharge coefficient (se) [95%CI] p value	Follow-up period coefficient (se) [95%CI] p value	Total costs in 6 months after discharge coefficient (se) [95%CI] p value
HAH (hospital)	0.85 (0.04) [0.77;0.94] 0.002	1.23 (0.08) [1.08;1.4] 0.002	1.11 (0.06) [1;1.25] 0.058	1.17 (0.10) [0.99;1.38] 0.070	1.20 (0.11) [1;1.43] 0.046	1.71 (0.20) [1.36;2.15] <0.001
Admission date	1 (0) [1;1] 0.076	1.00 (0.00) [1.00;1.00] 0.032	1 (0) [1;1] 0.833	1.00 (0.00) [1.00;1.00] 0.337	1 (0) [1;1] 0.075	1 (0) [1;1] 0.282
ICD10 primary	1 (0) [1;1] 0.692	1.00 (0.00) [1.00;1.00] 0.993	1 (0) [1;1] 0.126	1.00 (0.00) [1.00;1.00] 0.038	1 (0) [1;1] 0.282	1 (0) [1;1] 0.279
ICD10 secondary	1 (0) [1;1] 0.817	1.00 (0.00) [1.00;1.00] 0.473	1 (0) [1;1] 0.014	1.00 (0.00) [1.00;1.00] 0.024	1 (0) [1;1] 0.724	1 (0) [1;1] 0.801
2yrs pre AE costs	1 (0) [1;1] 0.08	1.00 (0.00) [1.00;1.00] 0.012	1 (0) [1;1] 0.461	1.00 (0.00) [1.00;1.00] 0.135	1 (0) [1;1] 0.435	1 (0) [1;1] 0.761
2yrs pre elective costs	1 (0) [1;1] 0.015	1.00 (0.00) [1.00;1.00] 0.046	1 (0) [1;1] 0.576	1.00 (0.00) [1.00;1.00] 0.429	1 (0) [1;1] 0.63	1 (0) [1;1] 0.725
2yrs pre non-elective costs	1 (0) [1;1] 0	1.00 (0.00) [1.00;1.00] <0.001	1 (0) [1;1] 0.651	1.00 (0.00) [1.00;1.00] 0.700	1 (0) [1;1] 0.199	1 (0) [1;1] 0.01
2yrs pre day case costs	1 (0) [1;1] 0.416	1.00 (0.00) [1.00;1.00] 0.158	1 (0) [1;1] 0.057	1.00 (0.00) [1.00;1.00] 0.023	1 (0) [1;1] 0.068	1 (0) [1;1] 0.064
2yrs pre geriatric ward costs	1 (0) [1;1] 0.031	1.00 (0.00) [1.00;1.00] 0.029	1 (0) [1;1] 0.625	1.00 (0.00) [1.00;1.00] 0.806	1 (0) [1;1] 0.484	1 (0) [1;1] 0.103
2yrs pre mental ward costs	1 (0) [1;1] 0.206	1.00 (0.00) [1.00;1.00] 0.166	1 (0) [1;1] 0.009	1.00 (0.00) [1.00;1.00] 0.020	1 (0) [1;1] 0.01	1 (0) [1;1] 0.004
2yrs pre outpatient costs	1 (0) [1;1] 0.236	1.00 (0.00) [1.00;1.00] 0.187	1 (0) [1;1] 0.748	1.00 (0.00) [1.00;1.00] 0.802	1 (0) [1;1] 0.798	1 (0) [1;1] 0.908
2yrs pre medication costs	1 (0) [1;1] 0.399	1.00 (0.00) [1.00;1.00] 0.383	1 (0) [1;1] 0.011	1.00 (0.00) [1.00;1.00] 0.016	1 (0) [1;1] 0.37	1 (0) [1;1] 0.77
Number of LTCs	1.08 (0.02) [1.04;1.12] 0	1.12 (0.03) [1.07;1.18] <0.001	1.03 (0.02) [0.99;1.08] 0.169	1.06 (0.04) [0.99;1.13] 0.076	1.06 (0.03) [1.01;1.13] 0.032	1.09 (0.04) [1.01;1.17] 0.026
Age on admission	1.01 (0) [1;1.01] 0.025	1.01 (0.00) [1.00;1.02] 0.048	1.01 (0) [1;1.01] 0.054	1.01 (0.01) [1.00;1.02] 0.254	1.02 (0.01) [1;1.03] 0.019	1.01 (0.01) [0.99;1.03] 0.171
Male	1.11 (0.06) [1;1.22] 0.051	1.12 (0.07) [0.99;1.26] 0.085	0.94 (0.06) [0.83;1.07] 0.353	0.97 (0.09) [0.80;1.17] 0.752	0.97 (0.09) [0.8;1.16] 0.716	1 (0.12) [0.79;1.26] 0.974
SES	1 (0.01) [0.98;1.02] 0.965	1 (0.01) [0.98;1.03] 0.778	1.02 (0.01) [1;1.04] 0.081	1.03 (0.01) [1.00;1.06] 0.023	1 (0.02) [0.96;1.03] 0.822	1 (0.02) [0.95;1.05] 0.951
Atrial Fibrillation	-----	-----	1.07 (0.07) [0.94;1.21] 0.305	1.09 (0.10) [0.92;1.29] 0.335	-----	-----
Arthritis	0.99 (0.05) [0.89;1.1] 0.889	0.96 (0.06) [0.85;1.1] 0.584	-----	-----	-----	-----
Cancer	-----	-----	1 (0.07) [0.88;1.15] 0.961	1.01 (0.10) [0.84;1.23] 0.899	-----	-----
CVD	1.04 (0.07) [0.91;1.2] 0.552	1.00 (0.09) [0.85;1.19] 0.956	1.14 (0.08) [1;1.3] 0.058	1.14 (0.11) [0.95;1.36] 0.174	1.12 (0.14) [0.88;1.43] 0.367	1.1 (0.17) [0.81;1.5] 0.531
Liver disease	1.35 (0.2) [1.01;1.8] 0.045	1.31 (0.21) [0.95;1.81] 0.097	-----	-----	-----	-----
Dementia	1.16 (0.07) [1.04;1.3] 0.009	1.17 (0.08) [1.01;1.35] 0.033	1.08 (0.07) [0.96;1.22] 0.195	1.11 (0.10) [0.93;1.31] 0.244	1.37 (0.16) [1.09;1.73] 0.008	1.49 (0.23) [1.09;2.02] 0.011
CHD	0.82 (0.06) [0.72;0.94] 0.004	0.79 (0.07) [0.67;0.93] 0.004	1.01 (0.07) [0.87;1.16] 0.941	1.03 (0.10) [0.85;1.24] 0.799	-----	-----
Epilepsy	-----	-----	1.08 (0.12) [0.86;1.35] 0.518	1.09 (0.17) [0.80;1.48] 0.581	-----	-----
Heart Failure	1.1 (0.07) [0.97;1.25] 0.131	1.08 (0.08) [0.93;1.26] 0.293	1.08 (0.08) [0.94;1.24] 0.287	1.07 (0.11) [0.88;1.31] 0.491	1.05 (0.13) [0.82;1.34] 0.719	1.01 (0.16) [0.74;1.39] 0.932
Multiple sclerosis	-----	-----	0.72 (0.14) [0.49;1.06] 0.095	0.66 (0.21) [0.35;1.25] 0.202	-----	-----
Parkinson's	1.19 (0.1) [1;1.41] 0.05	1.15 (0.13) [0.93;1.43] 0.19	1.22 (0.18) [0.91;1.64] 0.193	1.34 (0.27) [0.91;1.98] 0.139	-----	-----
Renal Failure	1.01 (0.06) [0.89;1.14] 0.911	1.00 (0.07) [0.87;1.16] 0.949	1.06 (0.08) [0.92;1.22] 0.443	1.06 (0.11) [0.86;1.29] 0.602	1.12 (0.15) [0.86;1.46] 0.411	1.19 (0.2) [0.85;1.66] 0.317
Diseases of blood	1.04 (0.06) [0.94;1.16] 0.414	1.04 (0.07) [0.92;1.19] 0.516	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	1.33 (0.15) [1.07;1.65] 0.01	1.37 (0.19) [1.04;1.81] 0.026
Constant	3.67 (13.85) [0;5959] 0.73	0.07 (0.31) [0;592.13] 0.558	1064.79 (5943.4) [0.02;60000000] 0.212	0.89 (6.96) [0;4301665] 0.988	101000000000 (1050000000000) [149.57;6810000000000000000] 0.015	1320000000 (18000000000) [0;5.67E+20] 0.124

Results of the sensitivity analysis

	site one (n=13,267)		site two (n=4,769)		site three (n=2110)	
	Total costs in follow-up (50% higher HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% lower HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% higher HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% lower HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% higher HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% lower HAH unit costs) coefficient (se) [95%CI] p value
HAH (hospital)	0.87 (0.03) [0.81;0.94] 0.001	0.77 (0.03) [0.71;0.84] 0	1.18 (0.05) [1.09;1.28] 0	0.81 (0.04) [0.74;0.9] 0	1.23 (0.09) [1.07;1.42] 0.004	1.07 (0.09) [0.91;1.25] 0.399
Admission date	1 (0) [1;1] 0.071	1 (0) [1;1] 0.048	1 (0) [1;1] 0.489	1 (0) [1;1] 0.3	1 (0) [1;1] 0.007	1 (0) [1;1] 0.012
ICD10 primary	1 (0) [1;1] 0.649	1 (0) [1;1] 0.671	1 (0) [1;1] 0.001	1 (0) [1;1] 0.001	1 (0) [1;1] 0.167	1 (0) [1;1] 0.16
ICD10 secondary	1 (0) [1;1] 0.588	1 (0) [1;1] 0.701	1 (0) [1;1] 0.148	1 (0) [1;1] 0.145	1 (0) [1;1] 0.875	1 (0) [1;1] 0.909
2yrs pre AE costs	1 (0) [1;1] 0.223	1 (0) [1;1] 0.261	1 (0) [1;1] 0.687	1 (0) [1;1] 0.561	1 (0) [1;1] 0.307	1 (0) [1;1] 0.267
2yrs pre elective costs	1 (0) [1;1] 0.909	1 (0) [1;1] 0.904	1 (0) [1;1] 0.537	1 (0) [1;1] 0.657	1 (0) [1;1] 0.896	1 (0) [1;1] 0.813
2yrs pre non-elective costs	1 (0) [1;1] 0	1 (0) [1;1] 0	1 (0) [1;1] 0.919	1 (0) [1;1] 0.458	1 (0) [1;1] 0.015	1 (0) [1;1] 0.021
2yrs pre day case costs	1 (0) [1;1] 0.099	1 (0) [1;1] 0.097	1 (0) [1;1] 0.006	1 (0) [1;1] 0.004	1 (0) [1;1] 0.131	1 (0) [1;1] 0.148
2yrs pre geriatric ward costs	1 (0) [1;1] 0.006	1 (0) [1;1] 0.005	1 (0) [1;1] 0.002	1 (0) [1;1] 0	1 (0) [1;1] 0.562	1 (0) [1;1] 0.713
2yrs pre mental ward costs	1 (0) [1;1] 0.905	1 (0) [1;1] 0.854	1 (0) [1;1] 0.005	1 (0) [1;1] 0.02	1 (0) [1;1] 0.09	1 (0) [1;1] 0.132
2yrs pre outpatient costs	1 (0) [1;1] 0.086	1 (0) [1;1] 0.088	1 (0) [1;1] 0.027	1 (0) [1;1] 0.026	1 (0) [1;1] 0.699	1 (0) [1;1] 0.675
2yrs pre medication costs	1 (0) [1;1] 0.713	1 (0) [1;1] 0.892	1 (0) [1;1] 0.136	1 (0) [1;1] 0.236	1 (0) [1;1] 0.713	1 (0) [1;1] 0.663
Died within 6months	1.03 (0.04) [0.95;1.11] 0.492	1.02 (0.04) [0.94;1.12] 0.572	1.05 (0.04) [0.97;1.14] 0.252	1.05 (0.05) [0.95;1.16] 0.38	1.06 (0.08) [0.91;1.23] 0.474	1.06 (0.09) [0.89;1.25] 0.517
Number of LTCs	1.08 (0.02) [1.05;1.11] 0	1.09 (0.02) [1.05;1.13] 0	1.04 (0.02) [1;1.07] 0.033	1.04 (0.02) [0.99;1.08] 0.093	1.06 (0.02) [1.01;1.1] 0.016	1.06 (0.03) [1.01;1.11] 0.019
Age on admission	1 (0) [1;1.01] 0.323	1 (0) [1;1.01] 0.452	1 (0) [1;1.01] 0.788	1 (0) [0.99;1.01] 0.789	1.01 (0.01) [1;1.02] 0.037	1.01 (0.01) [1;1.02] 0.055
Male	1.09 (0.04) [1.01;1.18] 0.035	1.1 (0.05) [1.01;1.2] 0.034	0.96 (0.04) [0.88;1.04] 0.311	0.95 (0.06) [0.85;1.07] 0.382	0.97 (0.07) [0.84;1.12] 0.686	0.97 (0.08) [0.82;1.14] 0.704
SES	1 (0.01) [0.98;1.02] 0.979	1 (0.01) [0.98;1.02] 0.954	1.01 (0.01) [1;1.02] 0.17	1.01 (0.01) [0.99;1.03] 0.205	1 (0.01) [0.97;1.03] 0.887	1 (0.02) [0.97;1.03] 0.917
Atrial Fibrillation	-----	-----	1.08 (0.05) [0.98;1.18] 0.104	1.1 (0.06) [0.98;1.23] 0.094	-----	-----
Arthritis	0.96 (0.04) [0.89;1.05] 0.392	0.96 (0.05) [0.88;1.05] 0.403	-----	-----	-----	-----
Cancer	-----	-----	1.04 (0.05) [0.95;1.14] 0.426	1.03 (0.06) [0.92;1.16] 0.566	-----	-----
CVD	1.02 (0.05) [0.92;1.13] 0.743	1.02 (0.06) [0.91;1.14] 0.794	1.07 (0.05) [0.98;1.18] 0.146	1.08 (0.07) [0.96;1.22] 0.199	1.09 (0.11) [0.91;1.32] 0.352	1.11 (0.12) [0.9;1.37] 0.324
Liver disease	1.21 (0.13) [0.98;1.48] 0.073	1.23 (0.14) [0.98;1.53] 0.074	-----	-----	-----	-----
Dementia	1.07 (0.05) [0.97;1.17] 0.16	1.07 (0.05) [0.97;1.18] 0.2	1.02 (0.05) [0.93;1.11] 0.738	0.99 (0.06) [0.88;1.1] 0.795	1.14 (0.11) [0.95;1.37] 0.153	1.14 (0.12) [0.94;1.4] 0.18
CHD	0.86 (0.05) [0.77;0.95] 0.004	0.85 (0.05) [0.76;0.95] 0.005	1.07 (0.05) [0.97;1.18] 0.174	1.02 (0.06) [0.9;1.15] 0.785	-----	-----
Epilepsy	-----	-----	1.04 (0.1) [0.86;1.26] 0.664	1.02 (0.12) [0.82;1.28] 0.841	-----	-----
Heart Failure	1.09 (0.05) [0.99;1.2] 0.095	1.09 (0.06) [0.98;1.21] 0.11	1.07 (0.06) [0.96;1.19] 0.201	1.09 (0.07) [0.96;1.24] 0.177	1.01 (0.1) [0.83;1.22] 0.947	1.02 (0.11) [0.82;1.25] 0.885
Multiple sclerosis	-----	-----	0.76 (0.1) [0.59;0.98] 0.033	0.73 (0.11) [0.54;0.99] 0.046	-----	-----
Parkinson's	1.23 (0.11) [1.04;1.45] 0.018	1.24 (0.12) [1.03;1.49] 0.021	1.07 (0.14) [0.84;1.37] 0.582	1.11 (0.18) [0.81;1.52] 0.512	-----	-----
Renal Failure	1.04 (0.05) [0.95;1.13] 0.436	1.03 (0.05) [0.93;1.13] 0.601	1.04 (0.05) [0.94;1.15] 0.408	1.06 (0.07) [0.94;1.2] 0.366	1.11 (0.11) [0.91;1.36] 0.3	1.12 (0.13) [0.9;1.39] 0.317
Diseases of blood	1.05 (0.05) [0.97;1.14] 0.246	1.05 (0.05) [0.96;1.15] 0.308	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	1.2 (0.11) [1;1.42] 0.044	1.22 (0.12) [1.01;1.48] 0.042
Constant	26.62 (74.48) [0.11;6410.63] 0.241	8.84 (27.52) [0.02;3945.99] 0.484	295178.8 (1199605) [102.52;850000000] 0.002	1223534 (6192074) [60.23;24900000000] 0.006	14800000000000 (12700000000000) [776224.7;2.84E+20] 0	3100000000(292000000) [292677.5;3.28E+21] 0.001

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

For peer review only

**The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.**

	Item No.	STROBE items	Location in manuscript where items are reported	RECORD items	Location in manuscript where items are reported
<b>Title and abstract</b>					
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	1a: page 1  1b: page 2	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included.  RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract.  RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	1.1: page 1  1.2: page 2  1.3: page 2
<b>Introduction</b>					
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	page 4		
Objectives	3	State specific objectives, including any prespecified hypotheses	page 4		
<b>Methods</b>					
Study Design	4	Present key elements of study	page 5		

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

		design early in the paper			
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	page 5-6		
Participants	6	(a) <i>Cohort study</i> - Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> - Give the eligibility criteria, and the sources and methods of selection of participants	6a: NA	RECORD 6.1: The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided.  RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided.	6.1: page 5-6  6.2 NA
		(b) <i>Cohort study</i> - For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> - For matched studies, give matching criteria and the number of controls per case	6b: page 6-8	RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	6.3 NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect	page 7-8	RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and	page 5, 7-8

		modifiers. Give diagnostic criteria, if applicable.		effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	page 6		
Bias	9	Describe any efforts to address potential sources of bias	page 6-8		
Study size	10	Explain how the study size was arrived at	page 6-8		
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	page 7-8		
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> - If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> - If applicable, explain how	12a: page 7-8  12b: page 8  12c: page 8  12d: 6-8		

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

		<p>matching of cases and controls was addressed</p> <p><i>Cross-sectional study</i> - If applicable, describe analytical methods taking account of sampling strategy</p> <p>(e) Describe any sensitivity analyses</p>	12e: page 8		
Data access and cleaning methods		..		<p>RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population.</p> <p>RECORD 12.2: Authors should provide information on the data cleaning methods used in the study.</p>	<p>12.1: page 5</p> <p>12.2: page 6</p>
Linkage		..		RECORD 12.3: State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	page 6
<b>Results</b>					
Participants	13	(a) Report the numbers of individuals at each stage of the study ( <i>e.g.</i> , numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed)	13a: page 9-10	RECORD 13.1: Describe in detail the selection of the persons included in the study ( <i>i.e.</i> , study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by	page 6, 8, 10



		(b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram	13b: page 9-10 13c: page 10	means of the study flow diagram.	
Descriptive data	14	(a) Give characteristics of study participants ( <i>e.g.</i> , demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) <i>Cohort study</i> - summarise follow-up time ( <i>e.g.</i> , average and total amount)	14a: page 9,12 14b: NA 14c: page 6,13		
Outcome data	15	<i>Cohort study</i> - Report numbers of outcome events or summary measures over time <i>Case-control study</i> - Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> - Report numbers of outcome events or summary measures	page 13		
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision ( <i>e.g.</i> , 95% confidence interval). Make clear which confounders were adjusted for and why they were included	16a: page 13, 15		

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

		(b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	16b: NA  16c: NA		
Other analyses	17	Report other analyses done— e.g., analyses of subgroups and interactions, and sensitivity analyses	page 15		
<b>Discussion</b>					
Key results	18	Summarise key results with reference to study objectives	page 15		
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	page 17	RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	page 17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	page 18-19		
Generalisability	21	Discuss the generalisability (external validity) of the study	page 15-16		

		results			
<b>Other Information</b>					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	page 19		
Accessibility of protocol, raw data, and programming code		..		RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	page 19

\*Reference: Benchimol EI, Smeeth L, Guttman A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.

\*Checklist is protected under Creative Commons Attribution ([CC BY](https://creativecommons.org/licenses/by/4.0/)) license.

# BMJ Open

## Should I stay or should I go? A retrospective propensity score matched analysis using administrative data of hospital-at-home for older people in Scotland

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-023350.R2
Article Type:	Research
Date Submitted by the Author:	19-Feb-2019
Complete List of Authors:	Tsiachristas, Apostolos; University of Oxford, Health Economics Research Centre, Nuffield Department of Population Health Ellis, Graham; Monklands Hospital, NHS Lanarkshire Buchanan, Scott; Information Services Division, National Services Scotland Langhorne, Peter; University of Glasgow, Institute of Cardiovascular and Medical Sciences Stott, David; Institute of Cardiovascular and Medical Sciences, University of Glasgow, Geriatric Medicine Shepperd, S; University of Oxford, Nuffield Department of Population Health
<b>Primary Subject Heading</b>:	Geriatric medicine
Secondary Subject Heading:	Health economics, Health services research
Keywords:	hospital-at-home, admission avoidance, intermediate care, costs, mortality, UK

SCHOLARONE™  
Manuscripts

1  
2  
3  
4  
5 Should I stay or should I go? A retrospective propensity score matched  
6 analysis using administrative data of hospital-at-home for older people in  
7 Scotland  
8  
9  
10

11 Apostolos Tsiachristas<sup>1</sup>, Graham Ellis<sup>2</sup>, Scott Buchanan<sup>3</sup>, Peter Langhorne<sup>4</sup>, David J Stott<sup>4</sup>, Sasha  
12 Shepperd<sup>1</sup>.  
13  
14  
15  
16  
17

18 <sup>1</sup> Nuffield Department of Population Health, University of Oxford, Oxford, UK  
19

20 <sup>2</sup> Monklands Hospital, NHS Lanarkshire, Glasgow, UK  
21

22 <sup>3</sup> Information Services Division, National Services Scotland, Edinburgh, UK  
23

24 <sup>4</sup> Institute of Cardiovascular and Medical Sciences, University of Glasgow, Glasgow, UK  
25  
26  
27  
28

29 Word Count: 4783  
30  
31  
32

33 Correspondence to: Apostolos Tsiachristas, Health Economics Research Centre, Nuffield Department  
34 of Population Health, Richard Doll building, Old Road Campus, OX3 7LF, Oxford, UK; Tel: +44(0)1865  
35 289470; email: [apostolos.tsiachristas@dph.ox.ac.uk](mailto:apostolos.tsiachristas@dph.ox.ac.uk)  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## Abstract

**Objectives:** To compare the characteristics of populations admitted to hospital-at-home services with the population admitted to hospital and assess the association of these services with healthcare costs and mortality.

**Design:** In a retrospective observational cohort study of linked patient level data, we used propensity score matching in combination with regression analysis.

**Participants:** Patients aged 65 years and older admitted to hospital-at-home or hospital.

**Interventions:** Three geriatrician-led admission avoidance hospital-at-home services in Scotland.

**Outcome measures:** Healthcare costs and mortality.

**Results:** Patients in hospital-at-home were older and more socioeconomically disadvantaged, had higher rates of previous hospitalization, and there was a greater proportion of women and people with several chronic conditions compared with the population admitted to hospital. The cost of providing hospital-at-home varied between the three sites from £628 to £2928 per admission. Hospital-at-home was associated with 18% lower costs during the follow-up period in site one (ratio of means 0.82; 95%CI: 0.76-0.89). Limiting the analysis to costs during the 6 months following index discharge, patients in the hospital-at-home cohorts had 27% higher costs (ratio of means 1.27; 95%CI: 1.14-1.41) in site one, 9% (ratio of means 1.09; 95%CI: 0.95-1.24) in site two and 70% in site three (ratio of means 1.70; 95%CI: 1.40-2.07) compared with patients in the control cohorts. Admission to hospital-at-home was associated with an increased risk of death during the follow-up period in all three sites (1.09, 95%CI: 1.00-1.19 site one; 1.29, 95%CI: 1.15-1.44 site two; 1.27, 95%CI: 1.06-1.54 site three).

**Conclusions:** Our findings indicate that in these three cohorts, the populations admitted to hospital-at-home and hospital differ. We cannot rule out the risk of residual confounding, as our analysis relied on an administrative data set and we lacked data on disease severity and type of hospitalised care received in the control cohorts.

### Strengths and limitations of the study

- The study used a large dataset from three of the largest Health Boards in Scotland.
- The retrospective cohort study has allowed inferences from real world evidence.
- Various sensitivity analyses helped to address uncertainty in the results.
- The major limitation of this type of non-randomised comparison is residual confounding.
- The lack of data on quality of life, as well as use of subsequent health, social, community and informal care is a limitation.

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For peer review only

## Introduction

Organising health systems to optimise the health outcomes of older people and contain costs is a priority as populations around the world age, and the demand for healthcare continues to rise. Despite a global policy emphasis on 'care closer to home'<sup>1</sup> and initiatives that seek to ease demand for hospital based healthcare, efforts to innovate and deliver healthcare services that provide an alternative to hospital admission for older people have been piecemeal and often lack a health system perspective. A lack of evidence to support decision-making has contributed to this. Avoiding admission to hospital by providing acute healthcare in people's homes, often as a hospital outreach service, is one of the more popular service innovations and yet there is uncertainty around the effectiveness and cost-effectiveness of this form of care.<sup>2</sup>

### Box 1 Description of each service

#### Hospital-at-home

The three hospital-at-home services are broadly similar, capacity ranged between 24 to 60 beds for the period of the analysis. Each is a geriatrician-led service that is supported by nurses (sometimes nurse practitioners) and therapy practitioners for the initial assessment; geriatricians and the multi-disciplinary team review patients in their homes and meet daily (a virtual ward round) to discuss patient cases and agree actions. Rehabilitation is available within the existing team with onward referral to community rehabilitation as required, and in one site rehabilitation is accessed through a parallel community rehabilitation services. Out of hours emergency cover is provided by primary care out-of-hours. Patients are referred to the service from GPs, sometimes through a central referral number or via step down from the acute hospital. The service offers access to diagnostics such as radiology, and intravenous fluids, antibiotics and oxygen. Cases are discussed daily with the multidisciplinary team at the virtual ward round and daily management plans agreed. In one site there is close working with the day hospital where patients can be referred for follow up or for investigations. Patients access investigations and treatment with the same speed as inpatients. The services support intravenous therapies in the home.

#### Hospital

The provision of hospital based acute health services varied among the sites; in one site there were three district general hospitals (1,653 beds) that provide acute health services to a mainly urban population of 652,230, with a total of 1,653 beds; in site two a hospital (550 beds) provides acute healthcare to a population of 180,130; and in site three there are two district general hospitals (825 beds) that provide healthcare to a population of 358,900, and acute admissions are via one of the hospitals.

The use of administrative data to evaluate service delivery interventions has the potential to provide a simple and efficient mechanism to provide real-world evidence about policy relevant service innovations, and embed evaluation into local decision-making. However, previous experience of using routine data in this area of research has been of mixed success due to a limited set of variables, missing data and the complexity of policy relevant questions that often require a broad and longer term perspective.<sup>3</sup> Administrative healthcare data collected in Scotland is unique in that it is population based, with little missing data. The aim of this study was to use these data to compare the characteristics of populations from three Health Boards who used a geriatrician-led hospital-at-home service with the population who received hospital care, and to assess the impact of these services on healthcare costs and mortality.



## Methods

### *Setting*

We used patient level data collected by three of the fourteen Scottish Health Boards of all patients aged 64 years and older, and who were admitted (referred to as the index admission) to either geriatrician-led admission avoidance hospital-at-home or inpatient hospital between August 2014 and December 2015 (17 months) in site one and site two, and between January 2015 and December 2016 (24 months) in site three. These services are commissioned by integrated health and social care boards that cover a population of almost 1.5 million in urban and rural areas. The Information Service Division (ISD), part of NHS Scotland, de-identified, cleaned and linked individual patient records to derive activity and costs related to periods before and after the index admissions. We obtained signed release forms from each Board's Caldicott guardian, and followed the ISD data sharing agreement.

### *Intervention*

The three service models of hospital-at-home provided an admission avoidance function that provided an alternative to inpatient hospital care, and had similar structures and functions; the main differences were in the capacity of the services and the organisation of services for rehabilitation. (Box 1)

### *Data sources*

Data were available for each person for two years prior to their index admission, and from the point of their index admission to six months after index discharge from hospital-at-home or hospital. Box 2 presents a full list of all variables included in the dataset. Figure 1 provides schematic examples of the differing calendar time periods studied before and after index admission for people admitted between August 2014 and December 2015 to hospital-at-home (Patients A and B) or hospital (Patients C and D) in site one. As this illustrates, the maximum follow-up period for each patient consisted of the period between index admission and index discharge and 6 months after index discharge. The data were collected via the data systems used in hospitals to collect patient data. Hospital-at-home activity data was submitted to ISD from the local systems of the three sites. The linked data set included acute inpatient, geriatric long stay and day case, mental health admissions, outpatient appointments accident and emergency attendances, community prescribing and death registrations.

Figure 1. Illustration of obtained data from site one

**Box 2. List of variables included in the dataset**

Costs of accidents and emergency attendances,  
 Costs of acute day cases,  
 Costs of acute elective hospitalisation,  
 Costs of acute non-elective hospitalisation,  
 Costs of geriatric wards,  
 Costs of mental health wards,  
 Costs of outpatient visits,  
 Costs of prescribed medication,  
 Costs of (re)admission to hospital-at-home.  
 Primary ICD-10 codes on index discharge,  
 Secondary ICD-10 codes on index discharge,  
 Length of stay of the index admission,  
 Age on index admission,  
 Gender,  
 Scottish Index of Multiple Deprivation (SIMD), 1 (most deprived) to 10 (most affluent)  
 Long-term conditions,  
 Date of death (if applicable),  
 Based on ICD-10 codes:  
 Cardiovascular disease (CVD) (I60-I69, G45)  
 Chronic obstructive pulmonary disorder (COPD) (J41-J44, J47),  
 Dementia (F00-F03, F05.1),  
 Diabetes (E10-E14),  
 Coronary heart disease (CHD, ICD10: I20-I25),  
 Heart failure (I500, I501, I509),  
 Renal failure (N03, N18, N19, I12, I13),  
 Epilepsy (G40, G41),  
 Asthma (J45, J46),  
 Atrial fibrillation (I48, MS, G35),  
 Cancer (C00-C97),  
 Arthritis (M05, M19, M45, M47, M460-M462, M464, M468, M469),  
 Parkinson's (G20-G22),  
 Chronic liver disease (K711, K713, K714, K717, K754),  
 Congenital problems (Q00-Q99),  
 Diseases of blood and blood forming organs (D50-D89),  
 Other diseases of the digestive system (K00-K122, K130-K839, K85X, K860-K93),  
 Other endocrine metabolic diseases (E00-E07, E15-E35, E70-E90)  
 Admitted to HAH or hospital.

*Selection of patients in the hospital-at-home and control cohorts*

We included patients aged 65 years and older, and who were classified as an unscheduled admission to general or geriatric medicine. In the control cohort, we excluded those with a diagnosis that would not be eligible for management through hospital-at-home; these exclusions included acute intracerebral crisis (intracerebral infections, trauma or haemorrhage), stroke and related codes, acute coronary syndromes and myocardial infarction, surgical emergencies including vascular, urological, gynaecological and general surgical presentations, orthopaedic diagnosis of fractures and trauma, cardiothoracic diagnoses, poisoning and complications of surgery. We also excluded from the control group those who had a diagnosis (i.e. primary and secondary ICD-10 code) that was not observed in any of the hospital-at-home admissions in each site (1081 patients in site one, 1405 in site two and in 451 in site three) (Figure 2). Each patient was counted as a single episode of healthcare.

### *Intervention costs*

We collected data on the costs of hospital-at-home using a template derived from the Cost-It tool of the World Health Organisation.<sup>4</sup> The cost categories included staff, training, transport, information and communication, clinical materials/equipment, support services, laboratory services, diagnostics, overheads and other costs. Clinician managers supported by finance staff in the three Health Boards completed this template based on the actual spending for the hospital-at-home service for the time periods covered by the ISD data. The cost per hospital-at-home admission was calculated by dividing the total costs of the hospital-at-home service by the total number of hospital-at-home admissions during the same period.

### *Statistical analysis*

We used an iterative approach to the analysis, starting with a description of the two cohorts (i.e. those admitted to hospital-at-home and those admitted to hospital) for each Health Board. We calculated means, standard deviations, and frequencies to describe differences in patient characteristics at index admission and tested differences using two sample t-test and Mann-Whitney test for continuous variables and Chi-square test for categorical variables. We also estimated the mean differences in resource utilisation costs (with bootstrapped standard errors) and the unadjusted relative risk of mortality between the two cohorts for each Health Board.

Further, we investigated the association of being admitted to hospital-at-home or hospital with mortality and cost over a minimum follow-up period of six months. To do this, we followed the Medical Research Council guidelines on performing natural experiments and scientific literature to adopt a step-wise strategy to select the propensity score matching (PSM) technique that most reduced observed confounding between the two cohorts in each Health Board.<sup>5-8</sup> First, we included all possible confounding variables available in the dataset (see Box 2 and Figure 2), and considered that the inclusion of covariates not associated with the treatment assignment would have little influence in the propensity score model.<sup>5</sup> Second, we matched the two cohorts in each site using a range of the most commonly used PSM techniques; these included Mahalanobis, 1-to-1, K-to-1, kernel, local linear regression, spline, and inverse probability weighting techniques. Second, the performance of each PSM technique on covariate balancing was assessed based on the mean and median percentage standardised bias as well as Rubin's B (the absolute standardized difference of the means of the linear index of the propensity score in the treated and (matched) non-treated group) and Rubin's R (the ratio of treated to (matched) non-treated variances of the propensity score index). Following Rubin's (2001) recommendation, we considered B less than 25 and R between 0.5 and 2 to indicate sufficient balance.<sup>9</sup> Third, we chose the PSM technique that had the lowest values on these performance indicators in each of the three Health Boards. We matched the two cohorts in each Health Board by

1  
2  
3 socio-demographic characteristics (i.e. age, gender, socio-economic status), diagnosis code (i.e.  
4 primary and secondary ICD-10 code) of index admission, morbidity (i.e. type of long-term condition,  
5 mortality during follow-up (for the analysis of cost), 2-year costs prior to the index admission (by cost  
6 category as listed in Box 1), and date of index admission (to account for seasonal trends).  
7  
8

9  
10 We performed a doubly robust estimation to further reduce confounding by using a regression  
11 analysis after performing the most suitable PSM technique and including the confounding variables  
12 listed above as covariates.<sup>10</sup> In the regression, we used generalised linear regression models (GLMs)  
13 with gamma distribution and log link to investigate the association of hospital-at-home with total costs  
14 during the follow-up period, and total costs in 6 months following index discharge. We also used GLMs  
15 with Poisson distribution and log link to estimate the relative risk of mortality. Robust standard errors  
16 were specified in all regression models. We calculated Kaplan-Meier survival curves, with and without  
17 using the weights from the PSM, and used log-rank tests to test the equality of the survival functions.  
18 There were few missing observations in the dataset and thus, complete case analysis was performed.  
19  
20  
21  
22  
23  
24

### 25 26 *Subgroup analysis*

27  
28 We conducted a sub-group analysis, running the same regression models used in the main analysis, to  
29 investigate the association of hospital-at-home services with costs and mortality for the population  
30 who had a diagnosis of dementia. We considered this population to be important due to their complex  
31 healthcare needs, and the increasing prevalence of dementia.<sup>11 12</sup> In a second subgroup analysis, we  
32 excluded patients who died during the follow-up period and investigated the association of hospital-  
33 at-home with costs. In both subgroup analyses, propensity score matching was performed to match  
34 sub-cohorts in each site.  
35  
36  
37  
38  
39

### 40 41 *Sensitivity analysis*

42  
43 In a univariate sensitivity analysis, we reduced and increased the intervention cost of admission  
44 avoidance hospital-at-home by 50%, as there are no standard unit costs to benchmark these types of  
45 services and we were concerned that costs for these services may vary due to economies of scale,  
46 size, experience, setting, human resource capacity, and error. This sensitivity analysis was expected to  
47 impact the costs during index admission and the costs of admission to hospital-at-home in the six  
48 months after discharge. In another sensitivity analysis, we estimated the E-value to assess how strong  
49 unmeasured confounding would have to be with both the treatment (i.e. admission to hospital-at-  
50 home) and outcome (i.e. costs and mortality) to fully explain away the estimated treatment effects,  
51 conditional on the measured confounders.<sup>13 14</sup>  
52  
53  
54  
55  
56  
57

### 58 59 *Patient involvement*

60 Patients were not involved in this retrospective analysis of administrative data.

## Results

### *Characteristics of the population cohorts*

After applying the exclusion criteria, 1737 patients were admitted to hospital-at-home in site one between August 2014 and December 2015 (17 months), 1463 patients were admitted to hospital-at-home in site two between January 2015 and December 2016 (24 months), and 433 patients were admitted to hospital-at-home in site three between August 2014 and December 2015 (17 months) (Figure 2). In the same period, there were 13139 patients admitted to 3 hospitals in site one, 3994 patients admitted to 1 hospital in site two, and 1844 patients admitted to 1 hospital in site three.

There were few differences between the hospital-at-home cohorts in the three sites, the main difference being that a larger proportion of the population in site two lived in a more affluent area (i.e. scored five or higher on the Scottish Index of Multiple Deprivation). Patients admitted to hospital-at-home were on average three to four years older than those admitted to hospital, were more likely to be female (range from 5 percentage points to 9 percentage points), and a higher proportion had more than four long-term conditions (approximately 7 percentage points) compared with patients admitted to hospital (Table 1). The largest difference between those admitted to hospital-at-home and to hospital in site one and site two was in the proportion of patients with dementia (10 percentage points higher in the hospital-at-home cohorts), while in site three it was the proportion of patients with renal failure (also 10 percentage points higher in the hospital-at-home cohort).

We compared the two cohorts in each site, from index admission to six months post discharge from hospital-at-home or hospital (Table 2). There was on average a higher percentage of deaths while receiving healthcare in hospital compared with those receiving healthcare in hospital-at-home (6% vs., 1% site one; 6% vs., 3% site two; 4% vs., 1% site three); and a higher percentage of deaths in the follow-up period, from admission to six months after discharge, in the groups that had received hospital-at-home (21% vs., 28% site one; 22% vs., 32% site two; 17% vs., 27% site three). Patients in the hospital-at-home cohort lived on average eight (site one), ten (site two), and twelve (site three) fewer days during the whole follow-up, and their index admission was on average fewer days in site one (mean unadjusted difference -2.64, 95%CI -2.97 to -2.31) and site three (mean unadjusted difference -2.02, 95%CI -2.66 to -1.37) and longer in site two (mean unadjusted difference 1.25, 95% CI 0.86 to 1.64).

The cost during a hospital-at-home admission was on average lower than hospital admission in site one (mean difference -£2318; 95%CI: £-2420 to £-2217) and site three (mean difference -£1096; 95%CI: £-1398 to £-793), and slightly lower (mean difference £-153; 95%CI: £-277; to £-29) in site two (Table 2). In the hospital-at-home cohort, these costs included the intervention costs of delivering the

1  
2  
3 service at home, which were £628 per admission and £113 per day in site one, £2928 per admission  
4 and £398 per day in site two, and £864.54 per admission and £117.57 per day in site three. In each  
5 Health Board, staff were the major driver of the cost of delivering hospital-at-home (site one 95%, site  
6 two 87%, site three 94%). Detailed information on the costs of delivering hospital at home are in  
7 Appendix 1.  
8  
9

10  
11  
12 Each of the three hospital-at-home cohorts incurred higher healthcare costs, driven by non-elective  
13 hospitalisation, prior to their index admission compared with the respective control cohort. Site one  
14 had on average 40% higher costs (mean difference £3219; 95%CI: £2513 to £3925), site two 56%  
15 higher costs (mean difference £5064; 95%CI: £3984 to £6143) and site three 57% higher costs (mean  
16 difference £4115; 95%CI: £2467 to £5764). In the six months following discharge from the index  
17 admission, costs were higher for each of the three hospital-at-home cohorts; in site one costs were  
18 on average 43% higher (mean difference £1839; 95%CI: £1423 to £2255), in site two they were 16%  
19 higher (mean difference £875, 95%CI: £156 to £1595), and in site three they were 92% higher (mean  
20 difference £3068, 95%CI: £2178 to £3958). The larger increase in costs in all sites was due to higher  
21 non-elective hospitalisation costs in the group who had received hospital-at-home care (mean  
22 difference £1517, 95%CI £1134 to 1899 site one; mean difference £529, 95%CI £-77 to 1135 site two;  
23 mean difference £2618, 95%CI £1779 to 3458 site three) during the six months follow-up.  
24  
25  
26  
27  
28  
29  
30  
31

32  
33 When the cost of the index admission was included in the analysis, the cost during follow-up (i.e.  
34 including the index admission and 6-months healthcare resource use after index discharge) was 6%  
35 lower (mean difference -£480, 95%CI: £-996 to £36) in the hospital-at-home cohort, compared with  
36 the control cohort in site one; while these costs were 8% higher in site two (mean difference £722,  
37 95%CI: £32 to £1413) and 35% higher in site three (mean difference £1973, 95%CI: £1019 to £2927).  
38  
39  
40

41  
42 Compared with the control cohort, the mean costs per day of being alive during the follow-up period  
43 were 13% (mean difference £-12; 95%CI: -17 to -6) lower in the hospital-at-home cohort in site one,  
44 while these costs were 34% higher (mean difference £37; 95%CI: 18 to 56) and 66% higher (mean  
45 difference £36; 95%CI: 18 to 53) in site two and site three respectively.  
46  
47  
48  
49  
50

51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
Figure 2 Flowchart of study population

Table 1 Patient characteristics at index admission

Variable	Site one		Site two		Site three	
	Control (n=13139)	HAH (n=1737)	Control (n=3994)	HAH (n=1463)	Control (n=1844)	HAH (n=433)
Mean age on admission (SD)	77.8 (7.78)	81.2 (7.21)**	78.5 (8.11)	82.2 (7.82)**	77.3 (7.81)	81.4 (7.12)**
Female	7,468 (57%)	1,096 (63%)**	2,102 (53%)	909 (62%)**	1037 (56%)	266 (61%)*
Higher than 4 on the SIMD	5,005 (38%)	609 (35%)**	1,960 (49%)	775 (53%)*	837 (45%)	192 (44%)
More than 4 chronic conditions	4,974 (38%)	777 (45%)**	1,664 (42%)	725 (50%)**	659 (36%)	185 (43%)**
Arthritis	3,431 (26%)	497 (29%)*	1,455 (37%)	572 (39%)	606 (33%)	155 (36%)
Asthma	1,370 (10%)	183 (11%)	497 (13%)	207 (14%)	177 (10%)	49 (11%)
Atrial fibrillation	3,659 (28%)	488 (28%)	1,555 (29%)	468 (32%)*	498 (27%)	126 (29%)
Cancer	3,749 (29%)	485 (28%)	1,261 (32%)	371 (25%)**	580 (31%)	124 (29%)
CVD	2,922 (22%)	467 (27%)**	763 (19%)	392 (27%)**	373 (20%)	114 (26%)**
Liver disease	499 (4%)	50 (3%)	183 (5%)	52 (4%)	72 (4%)	20 (5%)
COPD	3,641 (28%)	505 (29%)	1,083 (27%)	428 (29%)	510 (28%)	132 (31%)
Dementia	1,999 (15%)	439 (25%)**	665 (17%)	390 (27%)**	223 (12%)	74 (17%)**
Diabetes	2,985 (23%)	403 (23%)	948 (24%)	350 (24%)	410 (22%)	115 (27%)*
Epilepsy	459 (4%)	75 (4%)	146 (4%)	78 (5%)**	53 (3%)	10 (2%)
CHD	5,034 (38%)	733 (42%)**	1,425 (36%)	575 (39%)*	624 (34%)	141 (33%)
Heart failure	2,197 (17%)	404 (23%)**	744 (19%)	32 (23%)**	328 (18%)	109 (25%)**
MS	73 (1%)	6 (0%)	21 (1%)	17 (1%)*	14 (1%)	2 (1%)
Parkinson's	293 (2%)	66 (4%)**	82 (2%)	53 (4%)**	53 (3%)	20 (5%)
Renal failure	2,501 (19%)	394 (23%)**	780 (20%)	339 (23%)**	284 (15%)	110 (25%)**
Congenital problems	277 (2%)	38 (2%)	159 (4%)	51 (4%)	51 (3%)	9 (2%)
Diseases of blood	3,784 (29%)	553 (32%)**	1,143 (29%)	426 (29%)	485 (26%)	125 (29%)
Endocrine metabolic disease	4,505 (34%)	624 (36%)	1,737 (44%)	652 (45%)	642 (35%)	151 (35%)
Disease of digestive system	9,341 (71%)	1,249 (72%)	2,710 (68%)	1,006 (69%)	1145 (62%)	286 (66%)

\* p<0.05 \*\* p<0.01 in chi-square test for categorical and two sample t-test and Mann-Whitney test for continuous variables to test differences between HAH and control; HAH: hospital-at-home; SIMD ranges from 1 (most deprived) to 10 (most affluent); Note: a patient could be registered with more than one ICD-10 codes; SD: standard deviation

Table 2. Mortality, resource utilisation and costs

Variable	Site one			Site two			Site three		
	Control (n=13139)	HAH (n=1737)	Mean difference or risk ratio (95%CI)	Control (n=3994)	HAH (n=1463)	Mean difference or risk ratio (95%CI)	Control (n=1844)	HAH (n=433)	Mean difference or risk ratio (95%CI)
Died during index admission	844 (6%)	20 (1%)	0.18 (0.12;0.28)##	256 (6%)	47 (3%)	0.50 (0.37;0.68)##	78 (4%)	2 (1%)	0.11 (0.03;0.44)##
Died during follow-up including index admission	2787 (21%)	483 (28%)	1.31 (1.21;1.42)##	867 (22%)	471 (32%)	1.48 (1.35;1.63)##	319 (17%)	116 (27%)	1.55 (1.29;1.86)##
Means days alive during follow-up (SD)	159 (57)	151 (60)	-8.32 (-11.32;-5.32)	156 (57)	146 (66)	-10.10 (-14;-7)	163 (52)	151 (60)	-12 (-18;-6)
Mean length of index admission in days (SD)	8.18 (13.13)	5.54 (5.23)	-2.64 (-2.97;-2.31)	6.10 (8.74)	7.35 (5.50)	1.25 (0.86;1.64)	6.36 (11.27)	4.34 (4.19)	-2.02 (-2.66;-1.37)
Mean 2 year historical costs (SD)									
A&E	173 (260)	253 (289)	80 (65;94)	136 (224)	180 (238)	44 (28;60)	143 (214)	202 (248)	59 (31;87)
Elective hospital care	985 (4183)	956 (5586)	-28 (-352;295)	1027 (4040)	705 (3,287)	-321 (-519;-123)	981 (3733)	1036 (7738)	55 (-723;833)
Non-elective hospital care	4037 (9051)	6945 (11078)	2908 (2452;3364)	5101 (11716)	9593 (15081)	4,492 (3804;5179)	3978 (9063)	7832 (12784)	3854 (2591;5118)
Hospital day case	707 (2868)	439 (1318)	-269 (-340;-197)	625 (4186)	290 (1676)	-336 (-479;-193)	544 (2121)	358 (1139)	-186 (-334;-38)
Geriatric long stay	360 (3078)	504 (3430)	143 (-66;354)	117 (1824)	252 (2757)	135 (-13;283)	105 (1321)	229 (1221)	125 (14;235)
Mental ward	247 (3637)	367 (4865)	119 (-177;411)	347 (5019)	1053 (7839)	706 (265;1147)	220 (3231)	252 (2903)	32 (-329;393)
Outpatient	173 (204)	173 (200)	0 (-11;11)	222 (244)	206 (232)	-15 (-30;0)	212 (270)	201 (253)	-11 (-38;15)
Medication (GP prescriptions)	1468 (1675)	1733 (1796)	256 (187;341)	1524 (1738)	1883 (1989)	360 (253;466)	1034 (1661)	1221 (1621)	188 (30;346)
Total	8149 (12538)	11369 (14951)	3219 (2513;3925)	9098 (239)	14162 (477)	5,064 (3984;6143)	7217 (11478)	11333 (16071)	4115 (2467;5764)
Mean costs during index admission (SD)	3195 (4683)	877# (1336)	-2318 (-2420;-2217)	3426 (4473)	3273# (1217)	-153 (-277;-29)	2383 (3872)	1287 (2753)	-1096 (-1398;-793)
Mean costs 6 months after index discharge (SD)									
A&E	72 (130)	88 (117)	17 (11;22)	55 (124)	53 (105)	-2 (-9;4)	59 (101)	71 (113)	12 (-1;25)
Elective hospital care	305 (2284)	157 (1642)	-148 (-236;-60)	272 (1781)	204 (1928)	-68 (-190;53)	169 (1433)	313 (2440)	144 (-92;380)
Non-elective hospital care	2444 (5885)	3961 (7124)	1517 (1134;1899)	3942 (8203)	4471 (9597)	529 (-77;1135)	2029 (5281)	4648 (8767)	2618 (1779;3458)
Hospital day case	237 (1230)	73 (440)	-164 (-191;-138)	234 (1485)	96 (804)	-139 (-198;-79)	168 (985)	63 (320)	-105 (-162;-48)
Geriatric long stay	643 (5191)	1014 (5467)	371 (79;663)	218 (2158)	150 (1753)	-68 (-178;41)	320 (2400)	700 (3873)	381 (-73;834)
Mental ward	165 (2539)	206 (2113)	41 (-58;140)	299 (3508)	259 (2928)	-40 (-224;143)	211 (2803)	120 (1291)	-91 (-245;64)
Outpatient	54 (108)	45 (95)	-9 (-13;-5)	61 (116)	54 (105)	-8 (-14;-2)	65 (128)	67 (131)	2 (-12;16)
Medication (GP prescriptions)	392 (515)	415 (540)	23 (-5;52)	402 (546)	482 (627)	80 (45;115)	314 (504)	338 (566)	24 (-28;76)
Hospital-at-home	4 (56)	196 (446)	193 (170;216)	50 (444)	642 (1737)	592 (506;679)	7 (59)	90 (257)	83 (59;108)
Total	4316 (8928)	6155 (9990)	1839 (1423;2255)	5535 (9734)	6410 (10919)	875 (156;1595)	3342 (6990)	6410 (10614)	3068 (2178;3958)
Mean costs in follow-up (SD) including index admission	7513 (10510)	7031 (10110)	-480 (-996;36)	8961 (11394)	9683 (11072)	722 (32;1413)	5724 (8523)	7697 (10834)	1973 (1019;2927)
Mean costs per lived day in follow-up (SD)	83 (150)	72 (114)	-12 (-17;-6)	109 (178)	146 (304)	37 (18;56)	55 (96)	91 (165)	36 (18;53)

# it includes the interventions costs (i.e. £628 in site one, £2,928 in site two, and £865.54 in site three) and other costs occurred during the episode; ## Unadjusted Risk Ratio; SD: standard deviation



### *Selection of propensity score matching technique*

In the propensity score matched analysis, there were 1696, 925, and 427 patients in the hospital-at-home cohort and 11571, 3849, and 1683 patients in the hospital cohort in site one, site two, and site three respectively (Figure 2). Local linear regression matching was the best PSM technique to match the cohorts in site one and site three for costs and mortality, as it resulted in a lower mean (i.e. 1.5 and 1.8 respectively) and median (i.e. 1.2 and 1.6 respectively) percentage standardised bias, as well as the lowest Rubin's B (i.e. 9.4 and 9.6 respectively). Based on the same criteria, Kernell matching was selected to match the cohorts in site two. Rubin's R was within the suggested range (i.e. from 0.5 to 2) in the selected techniques. These results as well as the patient characteristics at index admission after propensity score matching are presented in Appendix 2. As this Appendix shows, the differences in patient characteristics between the compared cohorts were almost eliminated after propensity score matching.

### *Main propensity score matched analysis*

The results of the main analysis are presented in Panel A in Table 3. After propensity score matching and regression analysis, the healthcare cost for site one in hospital-at-home during the whole follow-up period (i.e. during index admission and over six months after discharge from the index admission) was on average 18% lower (ratio of means: 0.82; 95%CI: 0.76 to 0.89) than admission to hospital. When the cost of the index admission was excluded from the hospital-at-home and hospital cohorts, costs were on average 27% higher (ratio of means: 1.27; 95%CI: 1.14 to 1.41) for hospital-at-home compared with hospital in site one. In site two, the difference in costs between the hospital-at-home and hospital was close to zero (ratio of means: 1.00; 95%CI 0.92 to 1.09) during the whole follow-up period and 9% higher (although not statistically significant) (ratio of means: 1.09; 95%CI: 0.95 to 1.24) when the cost of the index admission was excluded. In site three, patients admitted to hospital-at-home had on average 15% higher (although not statistically significant) cost during the whole follow-up period (ratio of means: 1.15; 95%CI 0.99 to 1.33) and 70% higher cost when the cost of the index admission was excluded (ratio of means: 1.70; 95%CI 1.40 to 2.07) compared with patients admitted to hospital. The full results of the regression analyses are presented in Appendix 3.

There may be an increased risk of mortality in all three hospital-at-home cohorts (site one: relative risk 1.09; 95%CI 1.00 to 1.19) (site two: relative risk 1.29; 95%CI: 1.15 to 1.44) (site three: relative risk 1.27; 95%CI: 1.06 to 1.54) compared with the hospital cohort after PSM and regression were performed to adjust for confounding. The Kaplan-Meier survival curves presented in Figure 3 show higher survival rates in the inpatient control cohorts in all three sites, and after weighting with the propensity score the control cohort in site two continued to have a higher survival rate than the hospital-at-home cohort. The difference in survival in site three between the results reported in Table

3 and the survival curve after weighting is explained by the fact that Kaplan-Meier curves are only weighted with the propensity score without performing an additional regression analysis.

Table 3. Results of the propensity score matched regression analyses

Panel A: main analysis			
Outcome variable	Site one (n=13267)	Site two (n=4769)	Site three (n=2110)
Total costs during follow-up period <sup>#</sup>	0.82 (0.03) [0.76;0.89] <0.001	1.00 (0.05) [0.92;1.09] 0.982	1.15 (0.09) [0.99;1.33] 0.073
Total costs in 6 months after discharge	1.27 (0.07) [1.14;1.41] <0.001	1.09 (0.07) [0.95;1.24] 0.219	1.70 (0.17) [1.40;2.07] <0.001
Mortality rate during follow-up	1.09 (0.05) [1.00;1.19] 0.059	1.29 (0.07) [1.15;1.44] <0.0010	1.27 (0.12) [1.06;1.54] 0.011
Panel B: subgroup analysis including only patients with dementia			
Outcome variable	Site one (n=2321)	Site two (n=1053)	Site three (n=280)
Total costs during follow-up period <sup>#</sup>	0.76 (0.05) [0.66;0.87] <0.001	0.76 (0.06) [0.66;0.88] <0.001	0.87 (0.15) [0.63;1.21] 0.409
Total costs in 6 months after discharge	1.18 (0.11) [0.99;1.41] 0.071	0.75 (0.09) [0.59;0.96] 0.021	1.58 (0.41) [0.95;2.63] 0.078
Mortality rate during follow-up	1.05 (0.09) [0.89;1.24] 0.594	1.41 (0.12) [1.19;1.67] <0.001	1.65 (0.32) [1.12;2.41] 0.011
Panel C: subgroup analysis including only survivors			
Outcome variable	Site one (n=10132)	Site two (n=3584)	Site three (n=1691)
Total costs during follow-up period <sup>#</sup>	0.85 (0.04) [0.77;0.94] 0.002	1.11 (0.03) [1.00;1.25] 0.058	1.20 (0.11) [1.00;1.43] 0.046
Total costs in 6 months after discharge	1.23 (0.08) [1.08;1.40] 0.002	1.17 (0.10) [0.99;1.38] 0.070	1.71 (0.20) [1.36;2.15] <0.001
Panel D: sensitivity analysis			
Outcome variable	Site one (n=13267)	Site two (n=4769)	Site three (n=2110)
Total costs during follow-up period <sup>#</sup> (assuming 50% lower intervention costs)	0.77 (0.03) [0.71;0.84] <0.001	0.81 (0.04) [0.74;0.9] 0.001	1.07 (0.09) [0.91;1.25] 0.399
Total costs during follow-up period <sup>#</sup> (assuming 50% higher intervention costs)	0.87 (0.03) [0.81;0.94] 0.001	1.18 (0.05) [1.09;1.28] <0.001	1.23 (0.09) [1.07;1.42] 0.004

<sup>#</sup> It includes the index admission period and 6 months post-discharge; Note: The results are presented as coefficient (se) [95%CI] p value; The results are after matching and adjusting for age, gender, socio-economic status, primary and secondary ICD-10 codes of index admission, type of long-term condition, mortality (for the analysis of costs), 2-year costs prior to the index admission (by cost category as listed in Box 1).

Figure 3. Survival curves before and after propensity score matching

### Results of the subgroup analysis

Patients with dementia (Panel B in Table 3) admitted to hospital-at-home services in site one and site two had an average of 24% lower costs (site one: ratio of means 0.76; 95%CI 0.66 to 0.87; site two: ratio of means 0.76 95%CI: 0.66 to 0.88) from the index admission to six months post-discharge. We found that the population who were admitted to hospital-at-home, and had a diagnosis of dementia, may have an increased risk of death (site one: 1.05, 95% CI 0.89 to 1.24; site two: relative risk 1.41, 95%CI 1.19 to 1.67; site three: relative risk 1.65, 95%CI 1.12 to 2.41) compared with those who had a diagnosis of dementia and who were admitted to hospital.

When we excluded people who died during follow-up (i.e. during index admission and 6 months after discharge), patients admitted to hospital-at-home in site one had lower costs (ratio of means 0.85, 95%CI: 0.77 to 0.94), while there was 11% increase in costs in site two (ratio of means 1.11, 95%CI: 1.00 to 1.25) and 20% increase in site three (ratio of means 1.20, 95%CI: 1.00 to 1.43); the mean costs were higher in the hospital-at-home cohort when the costs during the index admission were excluded (site one: ratio of means 1.23, 95%CI: 1.08 to 1.40; site two: ratio of means 1.17, 95% CI 0.99 to 1.38; site three: ratio of means 1.71, 95% CI 1.36 to 2.15) compared with patients admitted to hospital (Panel C in Table 3).

### *Results of the sensitivity analyses*

The results from the sensitivity analysis (Panel D in Table 3) showed that patients in the hospital-at-home cohort in site one had 13% lower costs (ratio of means 0.87; 95%CI: 0.81 to 0.94) during the follow-up period (i.e. during index admission and 6 months after index discharge) when the hospital-at-home service costs were assumed to be 50% higher than in the main analysis. In site two, the results from the sensitivity analysis showed that the uncertainty in hospital-at-home service costs lead to increased costs or cost savings by about 18% (ratio of means 1.18; 95%CI: 1.09 to 1.28) during the whole follow-up period. In site three, the sensitivity analysis showed a 23% cost increase (ratio of means 1.23; 95%CI: 1.07 to 1.42), if the intervention costs of hospital-at-home were 50% higher. The estimated E-Values are presented in Appendix 4 and show that unmeasured confounders should be strongly associated with admission to hospital-at-home as well as with costs and mortality after adjusting for the observed confounders in order to explain away the results of the main analysis.

## Discussion

### *Main findings*

Patients who received healthcare from the hospital-at-home services were older, were more socioeconomically disadvantaged, had higher morbidity (measured by the number of long term conditions), higher rates of previous hospitalisation, and there was a greater proportion of women compared with the group admitted to hospital. The two groups also differed in terms of their clinical diagnosis, with the most marked difference across the three services being a greater percentage (five to ten percent difference) of people with dementia. The higher healthcare costs over the two years prior to index admission in those admitted to hospital-at-home were mainly driven by the costs of non-elective hospitalisation. However, the differences in patient characteristics were almost eliminated after propensity score matching. The cost of providing hospital-at-home varied between the three sites from £628 to £2928 per admission, and costs were driven primarily by staff costs. Our findings indicate that hospital-at-home might be associated with an increase in healthcare costs in the six months after index discharge. However, this increase in costs might be offset by likely cost-savings during the index admission. The higher healthcare cost at six months after index discharge, was driven primarily by acute non-elective hospitalisation. Interpreting this is not straightforward; it might indicate a lack of resources during the index admission to hospital-at-home, or an increased risk of hospital admission in the population who receive their healthcare through hospital-at-home. The suggestion of an increased risk of mortality at six months after the index admission might be genuine, or could indicate that propensity score matching did not control for all differences between the groups and thus, the estimates are subject to residual confounding.<sup>15 16</sup>

### *Comparison with previous studies*

A meta-analysis of six small randomised controlled trials concluded that admission avoidance hospital-at-home probably makes little or no difference to the risk of death or transfer to hospital at six months' follow-up, and might increase the likelihood of living at home (albeit with low-certainty evidence); and highlighted the lack of evidence on cost.<sup>2</sup> Studies that have used 'real life data' offer the potential to address criticisms of limited external validity from randomised trials; and propensity score matching is one technique that has been used to balance co-variables when analysing routinely collected health data to assess these type of service delivery interventions. Findings have been consistent, and previous studies have reported higher rates of mortality and unplanned admission for those who received an intermediate care intervention, compared with matched controls.<sup>6 16 17</sup> However, it is possible that these findings are subject to residual confounding.

### *Potential mechanisms and interpretation*

Healthcare services that cross the interface of primary and secondary care can bridge and strengthen the integration of acute and community services, and social care. However, by definition this can lead to a complex arrangement of services that reflect availability of local resources,<sup>18</sup> and a willingness to innovate. The hospital-at-home services evaluated in this analysis were established to reduce the demand for acute hospital beds by providing an alternative to admission to hospital, and to lower the risk of functional decline from the limited mobility that older people might experience when in hospital. However, it is possible that the services have several functions, for example by providing both rapid response and reablement, and this is reflected in the diverse population included in this analysis. Existing services and the overall structure of the healthcare care system in Scotland may also have influenced the shape and scope of hospital-at-home functions. Regarding the control cohorts, older people admitted to acute hospital in Scotland receive quite variable care and access to comprehensive geriatric assessment depending on whether they are placed in a geriatric medical unit or other environments such as general adult medicine. This variation may also have influenced the results of this study.

### *Implications for clinicians and policy makers*

The variation in intervention costs of the three hospital-at-home services is primarily driven by staff costs, and the findings of the sensitivity analysis confirms that staff costs are likely to determine whether a hospital-at-home service leads to higher costs or cost savings. The skill-mix of healthcare professionals who provide hospital-at-home should be guided by national standards, the type of patients the service targets, and the function of the service in terms of whether or not the service supplements existing community based healthcare, substitutes for hospital level care, augments palliative care services or a combination of these. The integration of these types of service with

1  
2  
3 existing primary and secondary care services, for example the provision of out-of-hours care by  
4 primary care services, might also determine the costs of these services. Managerial capacity of these  
5 services is expected to be of crucial importance in setting-up and managing the team of professionals  
6 able to provide high quality care.  
7  
8  
9

10 The absence of evidence based guidelines about who and under which conditions a patient may be  
11 admitted to admission avoidance hospital-at-home might explain the variation in the set-up of  
12 services, the difference in patient characteristics between patients admitted to hospital-at-home and  
13 hospital, and the relatively small size of the services. This is confirmed by the National Audit of  
14 Intermediate Care, <sup>19</sup> that was established in response to concerns about governance structures in  
15 intermediate care services, and reported a complex pattern of service provision.  
16  
17  
18  
19

20 Data on the role and capability of informal care givers is largely absent. In many cases, people admitted  
21 to hospital-at-home services receive care from their partners who if old might have health issues  
22 themselves.  
23  
24  
25

### 26 *Strengths and limitations*

27

28 The strengths of this study include the dataset from three of the largest Health Boards in Scotland, the  
29 quasi-experimental study design that has allowed inferences from real world evidence, and the  
30 sensitivity analyses that helped to address uncertainty in the results. The major limitation of this type  
31 of non-randomised comparison is residual confounding. While matching individuals and performing  
32 regression analysis can reduce this risk, it is possible that the two populations differed in frailty  
33 because we did not match and adjust for differences in the use of community and social services prior  
34 to index admission. If unobserved confounders were part of the clinical-decision making by GPs and  
35 geriatricians to admit patients to hospital-at-home or hospital, our findings might be biased due to  
36 confounding by clinical indication. This type of confounding is often not measured directly because  
37 standardised criteria are not available to guide clinical decision-making.<sup>20 21</sup> Therefore, the magnitude  
38 of this bias in our results depends on the clinical-decision making process to admit patients to hospital-  
39 at-home in the three sites. If clinicians did not consider hospital-at-home as a substitute service to  
40 hospitalisation then confounding by indication would increase the residual confounding in our  
41 analysis. GPs and geriatricians who refer patients to hospital-at-home are likely to have a clinical bias  
42 in preferring to keep older, frailer and terminally ill patients in their own home. Using hospital-at-  
43 home admission criteria to define the control cohort accepts that such open criteria will include  
44 general medical patients who are likely to have fewer comorbidities, be younger and with a longer life  
45 expectancy. However, as the results of the survivors' subgroup analysis were very similar with the  
46 results of the main cost analysis we expect that the magnitude of the residual confounding to be small.  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 Furthermore, the use of routine data has been used to reliably identify older people with frailty,<sup>22</sup> and  
4 approaches using clinical codes to define this population are being tested.<sup>23</sup>  
5  
6

### 7 *Future research*

8

9 Guidance on the use of real life data to evaluate service delivery interventions is largely absent, and  
10 could provide healthcare decision-makers with a relatively inexpensive way of evaluating local service  
11 innovations and how to avoid pitfalls in analysis and interpretations. Similar to all observational  
12 studies, the findings of this study may be used to identify important questions to be tested in  
13 randomised trials.<sup>20</sup> A multi-centre randomised trial that measures outcomes that are key to decision-  
14 makers (including informal care giving), and is accompanied by a process evaluation to help explain  
15 the findings, is necessary to provide clinicians and policy makers with further evidence about the  
16 effectiveness and cost-effectiveness of admission avoidance hospital-at-home services across UK. The  
17 authors are involved in such a trial the results of which are expected to be available in 2019.<sup>24</sup>  
18  
19  
20  
21  
22  
23  
24  
25

## 26 **Conclusions**

27

28 We found differences in the populations admitted to hospital-at-home and hospital. The likely higher  
29 cost in all three hospital-at-home cohorts, compared with the hospital cohorts during the six months  
30 following discharge, highlights the importance of characterising populations eligible to receive these  
31 types of healthcare services and of assessing subsequent use of health, social, and informal care  
32 following admission to hospital-at-home or hospital. The lack of data on the severity of the observed  
33 acute and chronic conditions as well as on type of hospitalised care received in the control cohorts  
34 means that we cannot rule out the risk of residual confounding, and the findings should be interpreted  
35 with caution.  
36  
37  
38  
39  
40  
41  
42

## 43 **Competing interests**

44

45 All authors have completed the ICMJE uniform disclosure form. GE is leading one of the hospital-at-  
46 home services in this study. All other authors declare no support from any organisation for the  
47 submitted work; no financial relationships with any organisations that might have an interest in the  
48 submitted work in the previous three years; no other relationships or activities that could appear to  
49 have influenced the submitted work.  
50  
51  
52  
53  
54  
55

## 56 **Details of contributors**

57

58 AT, GE, and SS were responsible for study concept, GE and SB facilitated the acquisition of data; AT  
59 and SS led the writing of the protocol, study design and drafting of the manuscript; AT performed the  
60

1  
2  
3 statistical analysis. PL and DS provided clinical expertise and commented on previous versions of the  
4 manuscript. All authors interpreted the data, critically revised the manuscript for important  
5 intellectual content and approved the final version for submission. AT and SS are guarantors.  
6  
7  
8  
9  
10

## 11 Acknowledgement

12  
13  
14 We would like to thank Charmaine Walker, Jenny Boyd, Alistair Smith and Josh Matthews from ISD  
15 Scotland for providing us with the data as well as Christine McGregor (economist in the Scottish  
16 Government) for her insightful views and expertise. We are also indebted to Dr Mike Gardner and Prof  
17 Alastair Gray (both University of Oxford), Prof Stavros Petrou (University of Warwick), and Dr Matthew  
18 Sperrin (University of Manchester) for commenting on previous drafts of the manuscript. Our thanks  
19 also to Prof Gillian Parker (University of York), Dr Angela Coulter (University of Oxford) and Prof Stuart  
20 Parker (University of Newcastle) for their useful reflection on the study findings. Finally, we would like  
21 to thank all healthcare staff in all three sites who made this study happen.  
22  
23  
24  
25  
26  
27  
28

## 29 Ethical approval

30  
31  
32 We obtained local data transfer agreements and signed release forms from each Health Board's  
33 Caldicott guardian. Further approval from an ethics committee was not required because the study  
34 was part of a service audit and the data provided to the researchers was de-identified.  
35  
36  
37  
38

## 39 Funding

40  
41  
42 NIHR, UK. (12/5003//01; "How to Implement Cost-Effective Comprehensive Geriatric Assessment")  
43  
44

## 45 Data sharing agreement

46  
47  
48 No additional data are available.  
49  
50

## 51 References

- 52  
53  
54  
55 1. World Health Organization. Noncommunicable diseases progress monitor 2015. Geneva: World  
56 Health Organization, 2015.  
57 2. Shepperd S, Iliffe S, Doll HA, et al. Admission avoidance hospital at home. *Cochrane Database Syst*  
58 *Rev* 2016;9:CD007491. doi: 10.1002/14651858.CD007491.pub2  
59 3. Sherman RE, Anderson SA, Dal Pan GJ, et al. Real-World Evidence - What Is It and What Can It Tell  
60 Us? *N Engl J Med* 2016;375(23):2293-97. doi: 10.1056/NEJMSb1609216

- 1
  - 2
  - 3
  4. Johns B, Baltussen R, Hutubessy R. Programme costs in the economic evaluation of health interventions. *Cost effectiveness and resource allocation : C/E* 2003;1(1):1.
  - 5
  - 6
  - 7
  - 8
  - 9
  - 10
  - 11
  - 12
  - 13
  - 14
  - 15
  - 16
  - 17
  - 18
  - 19
  - 20
  - 21
  - 22
  - 23
  - 24
  - 25
  - 26
  - 27
  - 28
  - 29
  - 30
  - 31
  - 32
  - 33
  - 34
  - 35
  - 36
  - 37
  - 38
  - 39
  - 40
  - 41
  - 42
  - 43
  - 44
  - 45
  - 46
  - 47
  - 48
  - 49
  - 50
  - 51
  - 52
  - 53
  - 54
  - 55
  - 56
  - 57
  - 58
  - 59
  - 60
5. Stuart EA. Matching methods for causal inference: A review and a look forward. *Statistical science : a review journal of the Institute of Mathematical Statistics* 2010;25(1):1-21. doi: 10.1214/09-STS313
  6. Garrido MM, Kelley AS, Paris J, et al. Methods for constructing and assessing propensity scores. *Health Serv Res* 2014;49(5):1701-20. doi: 10.1111/1475-6773.12182
  7. Baser O. Too much ado about propensity score models? Comparing methods of propensity score matching. *Value Health* 2006;9(6):377-85. doi: 10.1111/j.1524-4733.2006.00130.x
  8. Craig P, Cooper C, Gunnell D, et al. Using natural experiments to evaluate population health interventions: new Medical Research Council guidance. *J Epidemiol Community Health* 2012;66(12):1182-6. doi: 10.1136/jech-2011-200375
  9. Rubin DB. Using propensity scores to help design observational studies: application to the tobacco litigation. *Health Services & Outcomes Research Methodology* 2001;2:169-88.
  10. Funk MJ, Westreich D, Wiesen C, et al. Doubly robust estimation of causal effects. *Am J Epidemiol* 2011;173(7):761-7. doi: 10.1093/aje/kwq439
  11. Leist AK. Social Inequalities in Dementia Care, Cure, and Research. *J Am Geriatr Soc* 2017;65(5):1100-01. doi: 10.1111/jgs.14893
  12. World Health Organization. Draft global action plan on the public health response to dementia, 2016.
  13. VanderWeele TJ, Ding P. Sensitivity Analysis in Observational Research: Introducing the E-Value. *Ann Intern Med* 2017;167(4):268-74. doi: 10.7326/M16-2607
  14. Liu W, Kuramoto SJ, Stuart EA. An introduction to sensitivity analysis for unobserved confounding in nonexperimental prevention research. *Prev Sci* 2013;14(6):570-80. doi: 10.1007/s11121-012-0339-5
  15. Iliffe S. Hospital at home: from red to amber?. Data that will reassure advocates-but without satisfying the sceptics. *Bmj* 1998;316(7147):1761-2.
  16. Steventon A, Bardsley M, Billings J, et al. The role of matched controls in building an evidence base for hospital-avoidance schemes: a retrospective evaluation. *Health Serv Res* 2012;47(4):1679-98. doi: 10.1111/j.1475-6773.2011.01367.x
  17. Lewis G, Vaithianathan R, Wright L, et al. Integrating care for high-risk patients in England using the virtual ward model: lessons in the process of care integration from three case sites. *Int J Integr Care* 2013;13:e046.
  18. Young J, Gladman JR, Forsyth DR, et al. The second national audit of intermediate care. *Age Ageing* 2015;44(2):182-4. doi: 10.1093/ageing/afu174
  19. NHS Benchmarking Network. Summary report- England. National audit of intermediate care: NHS Benchmarking Network, 2017.
  20. Freemantle N, Marston L, Walters K, et al. Making inferences on treatment effects from real world data: propensity scores, confounding by indication, and other perils for the unwary in observational research. *Bmj* 2013;347:f6409. doi: 10.1136/bmj.f6409
  21. Wong AY, Root A, Douglas IJ, et al. Cardiovascular outcomes associated with use of clarithromycin: population based study. *Bmj* 2016;352:h6926. doi: 10.1136/bmj.h6926
  22. Clegg A, Bates C, Young J, et al. Development and validation of an electronic frailty index using routine primary care electronic health record data. *Age Ageing* 2017 doi: 10.1093/ageing/afx001
  23. Ham C, York N, Sutch S, et al. Hospital bed utilisation in the NHS, Kaiser Permanente, and the US Medicare programme: analysis of routine data. *Bmj* 2003;327(7426):1257. doi: 10.1136/bmj.327.7426.1257
  24. Shepperd S, Craddock-Bamford A, Butler C, et al. A multi-centre randomised trial to compare the effectiveness of geriatrician-led admission avoidance hospital at home versus inpatient admission. *Trials* 2017;18(1):491. doi: 10.1186/s13063-017-2214-y



1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

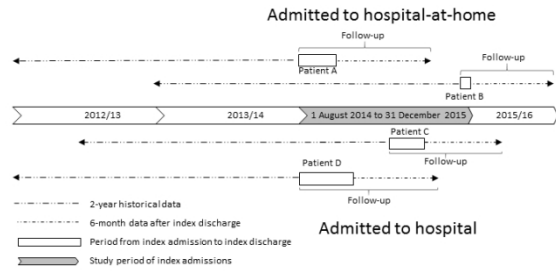


Figure 1. Illustration of obtained data from site one  
338x190mm (96 x 96 DPI)

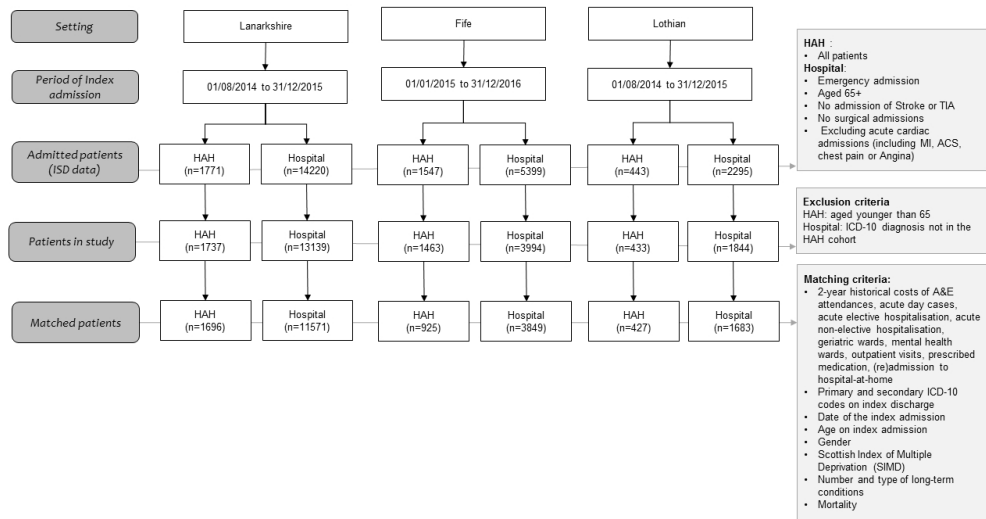
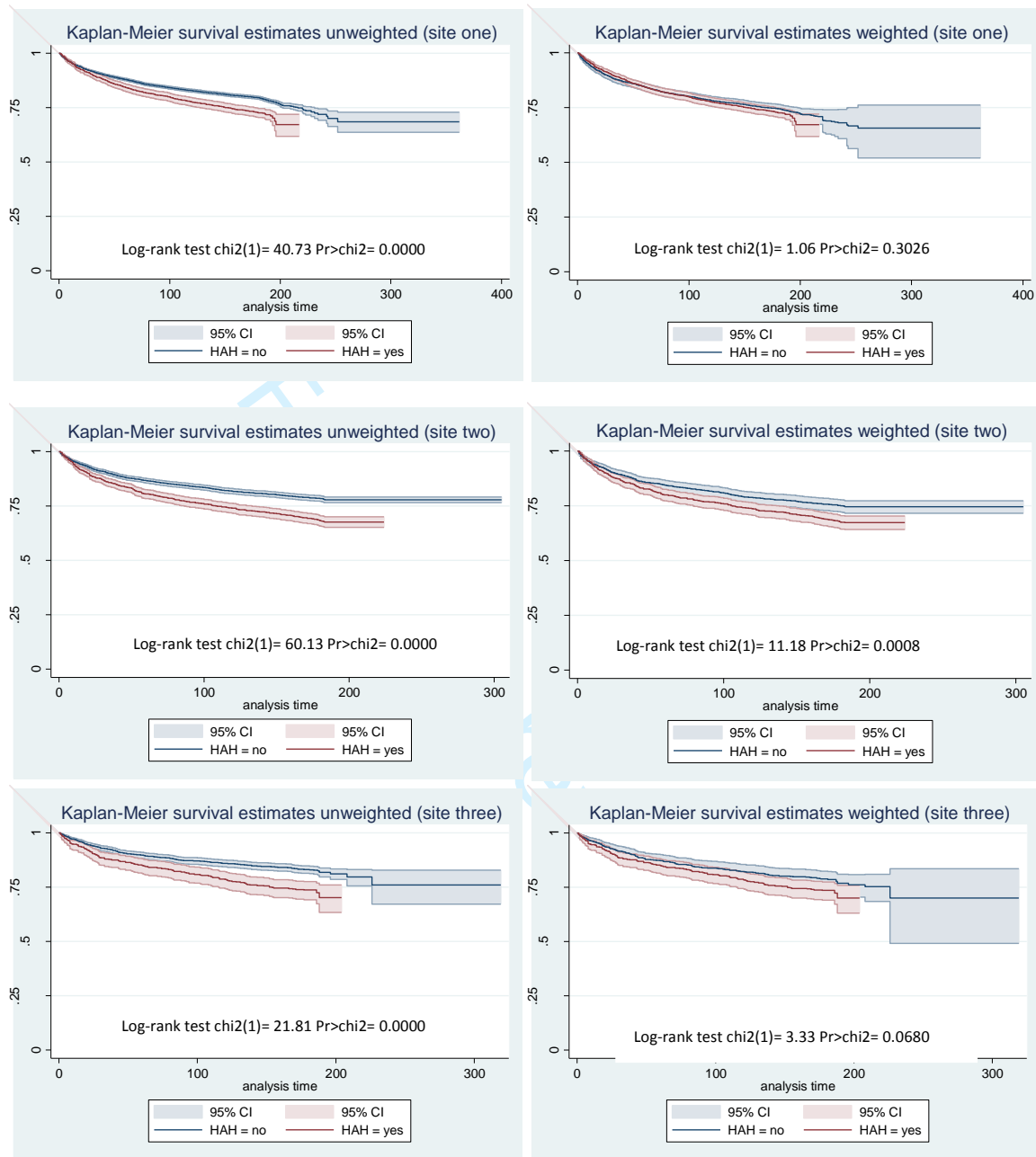


Figure 2 Flowchart of study population

338x190mm (96 x 96 DPI)

Figure 3. Survival curves before and after propensity score matching



Note: The cohorts in each site were matched on age, gender, socio-economic status, primary and secondary ICD-10 codes of index admission, type of long-term condition, 2-year costs prior to the index admission (by cost category as listed in Box 1); Weighted refers to weighting the observation of each patient based on the propensity score to be in the hospital-at-home cohort as described in the propensity score matching section.

Appendix 1. Calculation of admission avoidance hospital-at-home in each site

Site one		PERIOD				
from:	01/08/2014 (dd/mm/yyyy)	Until:	01/01/2016 (dd/mm/yyyy)			
		17 Months				
Number of HAH admissions (in period)		1771	Source of ISD IPD data (1/8/14-31/12/15)			
Length of HAH stay per episode (in)		5.53886 Mean 0.125605 Standard error	ISD IPD data (1/8/14-31/12/15)			
HAH bed days (period)		9809				
<b>A.1. Staff costs</b>						
No	Profession	WTEs	Gross	Summary salary	Source of	Total
<b>a) Medical staff</b>						
1	Consultant	1.50	£151,596		Business	£227,394
2	Agency consultant	0.16	£156,926		Business	£25,651
3	Consultant	1.07	£119,710		Business	£127,767
<b>b) Nursing and pharmacy services</b>						
1	Band 3 nurse	3.00	£24,790		Business	£74,369
2	Band 6 nurse	1.49	£41,425		Business	£61,740
3	Band 5 Bank nurse	0.71	£32,885		Business	£23,399
4	Band 6 Bank nurse	0.36	£38,471		Business	£13,687
5	Band 7 pharmacist	0.71	£55,491		Business	£39,484
6	Band 5 nurse	0.16	£37,036		Business	£6,054
7	Band 6 nurse	1.42	£42,342		Business	£60,303
8	Band 7 nurse	1.00	£42,444		Business	£42,444
9	Band 8a nurse	0.71	£53,126		Business	£37,801
<b>c) Allied health professions</b>						
1	Band 6 occupational therapist	2.59	£35,489		Business	£91,793
2	Band 6 physiotherapist	1.16	£46,585		Business	£54,200
3	Band 4 assistant practitioners for rehab	3.59	£24,660		Business	£88,444
4	Band 6 physiotherapy	0.71	£46,848		Business	£33,334
<b>d) Administration, ICT and management</b>						
1	Band 2 admin/clerical	0.30	£19,346		Business	£5,804
2	Band 3 admin/clerical	1.00	£23,948		Business	£23,948
3	Band 3 admin/clerical	0.71	£21,353		Business	£15,193
<b>e) Support services staff</b>						
1						£0
<b>Total</b>						<b>£1,052,80</b>
<b>A.2. Training costs</b>						
Note: the time to attend a course should be included in						
No.	Profession	Number of	Cost per	Summary costs	Source of	Total
1	Acute urgent care course	20	£250			£5,000
2	Prescribing course	3	£310			£930
<b>Total</b>						<b>£5,930</b>
<b>A.3. Transport costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Travel and subsistence			£37,918	Business	£37,918
<b>Total</b>						<b>£37,918</b>
<b>A.4. Information and communication costs (e.g. brochures and leaflets for patients and their</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1						£0
<b>Total</b>						<b>£0</b>
<b>A.5. Clinical materials/equipment and</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Instruments and sundries			£2,867	Business	£2,867

2	Equipment repairs clinical			£585	Business	£585
3	Surgical appliances			£104	Business	£104
4	Drugs			£1,693	Business	£1,693
5	Equipment purchase clinical			£298	Business	£298
<b>Total</b>						<b>£5,546</b>
<b>A.6. Support services supplies</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Catering			£177	Business	£177
2	Uniforms			£552	Business	£552
3	Printing and stationery			£737	Business	£737
4	Dressings			£473	Business	£473
5	general services			£16	Business	£16
<b>Total</b>						<b>£1,955</b>
<b>A.7. Labs and diagnostics</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Diagnostic supplies			£559	Business	£559
<b>Total</b>						<b>£559</b>
<b>A.8. Overhead costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Telephone			£3,794	Business	£3,794
2	Building			£119	Business	£119
3	Miscellaneous			£34	Business	£34
<b>Total</b>						<b>£3,947</b>
<b>A.9. Other costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Equipment purchase non medical			£3,354	Business	£3,354
2	postage			£772	Business	£772
<b>Total</b>						<b>£4,126</b>
<b>A.10. Additional costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1						£0
<b>Total</b>						<b>£0</b>
<b>TOTAL</b>						<b>£1,112,79</b>
<b>Unit cost of HAH admission</b>						<b>£628.34</b>
<b>Unit cost of HAH bed day</b>						<b>£113.44</b>

Site two		PERIOD				
from:	01/01/2015 (dd/mm/yyyy)	Until:	01/01/2017 (dd/mm/yyyy)			
		24 Months				
Source of						
<b>Number of HAH admissions (in period)</b>	1547	ISD IPD data				
<b>Length of HAH stay per episode (in</b>	7.35 Mean	ISD IPD data				
	0.14 Standard error					
<b>HAH bed days (period)</b>	11376					
<b>A.1. Staff costs</b>						
No	Profession	WTEs	Gross Summary salary	Source of	Total	
<b>a) Medical staff</b>						
1	Senior medical		£82,099	Business	£82,099	
2	Professional fees and charges		£124,391	Business	£124,391	
<b>b) Nursing and pharmacy services</b>						
1	Nursing & Midwifery-trained		£2,904,576	Business	£2,904,576	
2	Nursing & Midwifery-untrained		£627,532	Business	£627,532	
3	Pharmacists		£43,715	Business	£43,715	
4	Pharmacy Technicians		£14,471	Business	£14,471	
<b>c) Allied health professions</b>						
1				Business	£0	
<b>d) Administration, ICT and management</b>						
1	Admin Clerical		£126,018	Business	£126,018	
<b>e) Support services staff</b>						
1					£0	
<b>Total</b>					<b>£3,922,80</b>	
<b>A.2. Training costs</b>						
Note: the time to attend a course should be included in						
No.	Profession	Number of	Cost per	Summary costs	Source of	Total
1	Training costs			£1,512		£1,512
<b>Total</b>					<b>£1,512</b>	
<b>A.3. Transport costs</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Transport			£25,711	Business	£25,711
2	Travel And Subsistence			£340,388		£340,388
<b>Total</b>					<b>£366,099</b>	
<b>A.4. Information and communication costs (e.g. brochures and leaflets for patients and their</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1						£0
<b>Total</b>					<b>£0</b>	
<b>A.5. Clinical materials/equipment and</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Drugs			£203,900	Business	£203,900
2	Equipment			£14,589	Business	£14,589
3	Paramedical Supplies			£3,015	Business	£3,015
4	Surgical Appliances			£18	Business	£18
5	Surgical Sundries			£80,855	Business	£80,855
<b>Total</b>					<b>£302,377</b>	
<b>A.6. Support services supplies</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Bedding And Linen			£112	Business	£112
2	Cleaning			£8,251	Business	£8,251
3	General Services			£2,595		£2,595
<b>Total</b>					<b>£10,958</b>	
<b>A.7. Labs and diagnostics</b>						
No.	Cost item	Number of	Cost per item	Summary costs	Source of	Total
1	Cssd/diagnostic Supplies			£3,783		£3,783

							£3,783
<b>A.8. Overhead costs</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of		Total
1	Post Carriage And Telephones			£5,224			£5,224
2	Printing And Stationery			£5,737	Business		£5,737
3	Property Maintenance			£1,174			£1,174
4	Miscellaneous			£25	Business		£25
<b>Total</b>							<b>£12,160</b>
<b>A.9. Other costs</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of		Total
1	Provisions			£6	Business		£6
2	Uniforms			£334	Business		£334
<b>Total</b>							<b>£340</b>
<b>A.10. Additional costs</b>							
No.	Cost item	Number of	Cost per item	Summary costs	Source of		Total
1	Other Operating Income**			-£92,377			-£92,377
<b>Total</b>							<b>-£92,377</b>
<b>TOTAL</b>							<b>£4,527,65</b>
<b>Unit cost of HAH admission</b>							<b>£2,926.73</b>
<b>Unit cost of HAH bed day</b>							<b>£398.01</b>

**Site three**

	from:	<input type="text" value="01/01/2015"/> (dd/mm/yyyy)	PERIOD Until:	<input type="text" value="01/01/2016"/> (dd/mm/yyyy)	12 Months
Number of HAH admissions (in period)	<input type="text" value="598"/> 598		Source	of	<input type="text" value="ISD IPD data"/> business case
Length of HAH stay per episode (in days)	<input type="text" value="7.35"/> <input type="text" value="0.14"/>	Mean Standard error			<input type="text" value="ISD IPD data"/>
HAH bed days (period)	<input type="text" value="4397"/>				

A.1. Staff costs							
No.	Profession	WTEs	Gross annual	Summary salary cost	Source	of	Total
<b>a) Medical staff</b>							
1	Consultant	1		£114,776	Business		£114,77
2	Specialty doctor	1		£79,224	Business		£79,224
3					Business		£0
4							£0
5							£0
<b>b) Nursing and pharmacy services</b>							
1	Nurse (Band 6)	3		£125,484	Business		£125,48
2	Nurse (Band 5)	1.6		£53,256	Business		£53,256
<b>c) Allied health professions</b>							
1	Occupational therapist	1		£45,156	Business		£45,156
2	Physiotherapist	1		£45,156	Business		£45,156
<b>d) Administration, ICT and management</b>							
1	Admin Clerical	1		£23,664	Business		£23,664
<b>e) Support services staff</b>							
1							£0
<b>Total</b>							<b>£486,71</b>
A.2. Training costs							
Note: the time to attend a course should be included in							
No.	Profession	Number of	Cost per	Summary costs	Source	of	Total
1	Training costs			£1,000			£1,000
<b>Total</b>							<b>£1,000</b>
A.3. Transport costs							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1	Transport/travel			£20,000	Business		£20,000
<b>Total</b>							<b>£20,000</b>
A.4. Information and communication costs (e.g. brochures and leaflets for patients and their family)							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1							£0
<b>Total</b>							<b>£0</b>
A.5. Clinical materials/equipment and drugs							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1	Drugs			£4,840	Business		£4,840
2	Medical supplies			£2,393	Business		£2,393
<b>Total</b>							<b>£7,233</b>
A.6. Support services supplies							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1							£0
<b>Total</b>							<b>£0</b>
A.7. Labs and diagnostics							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total
1							£0
<b>Total</b>							<b>£0</b>
A.8. Overhead costs							
No.	Cost item	Number of	Cost per item	Summary costs	Source	of	Total



1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1	Phones, stationary etc.			£1,796	Business		£1,796
	<b>Total</b>						<b>£1,796</b>
<b>A.9. Other costs</b>							
No.	Cost item	Number	of	Cost per item	Summary costs	Source	of Total
1	Mischellaneous				£250		£250
	<b>Total</b>						<b>£250</b>
<b>A.10 Additional costs</b>							
No.	Cost item	Number	of	Cost per item	Summary costs	Source	of Total
1							£0
	<b>Total</b>						<b>£0</b>
						<b>TOTAL</b>	<b>£516,99</b>
						Unit cost of HAH admission	<b>£864.54</b>
						Unit cost of HAH bed day	<b>£117.57</b>

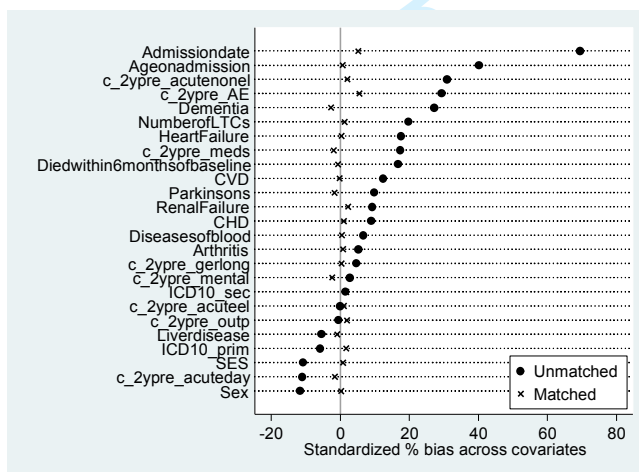
For peer review only

Appendix 2 Results of selecting PSM technique and plots of covariance balance before and after propensity score matching

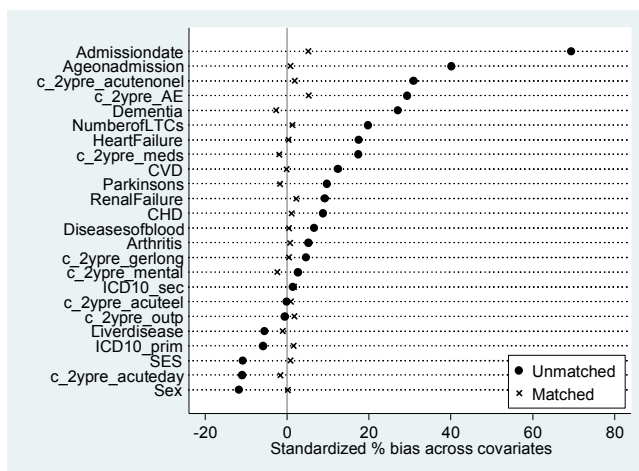
Variable	Site one		Site two		Site three	
	Costs	Survival	Costs	Survival	Costs	Survival
	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R	mean/median bias;Rubin's B/R
Mahalanobis	7.5/4.2;51.4/1.56	7.2/3.7;48.6/1.54	7.6/6.7;46.1/1.54	7.3/6.7;43.9/1.53	6.3/4.7/38.4/1.69	6.3/3.5/38.4/1.52
1-to-1	2.9/2.8;14.1/0.90	1.9/1.6;12.1/0.84	1.4/1.4;9.4/0.97	2.2/2.2;14.6/1.14	2.7/2.7/14.6/1.02	2.3/2.6/14.9/0.73
K-to-1	1.9/1.6;11.3/0.76	1.9/1.5;12.0/0.81	1.8/1.5;11.0/0.83	2.4/2.4;13.6/0.76	3.6/2.9/16.5/0.99	2.8/2.0/16.5/0.94
Kernel	1.6/1.1;9.8/0.97	1.5/1.2;8.9/0.92	1.1/0.9;6.9/1.02	0.9/0.7;6.5/1.01	2.2/1.6/12.3/1.22	1.9/1.2/11.2/1.21
Local linear regression	1.5/1.2;9.4/0.89	1.6/1.4;9.4/0.89	1.7/1.0;11.0/0.32	2.3/1.4;12.8/0.43	1.8/1.6/9.6/1.27	1.6/1.2/8.5/1.35
Spline	2.9/2.6;15.7/0.94	2.4/2.0;14.9/0.91	3.2/2.6;17.5/0.46	3.2/2.3;21.0/1.07	3.9/3.1/21.6/0.47	3.9/2.3/25.7/1.02
IPW	11.5/5.8;83.2/0.76	11.5/5.6;83.1/0.75	11.6/8.3;61.3/0.92	11.2/7.8;60.2/0.89	10.5/8.5/52.2/0.77	10.2/8.5/50.9/0.77

Rubin's B: the absolute standardized difference of the means of the linear index of the propensity score in the treated and (matched) non-treated group; Rubin's R: the ratio of treated to (matched) non-treated variances of the propensity score index; Samples sufficiently balanced if B less than 25 and that R between 0.5 and 2.

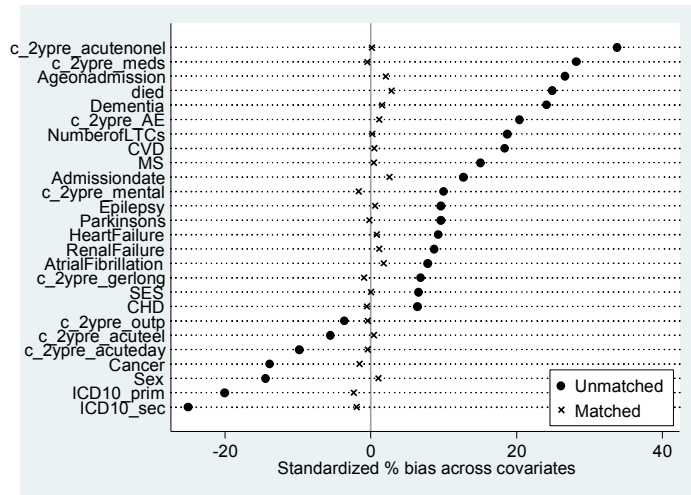
Standardised percentage bias before and after local linear regression propensity score matching for costs in site one



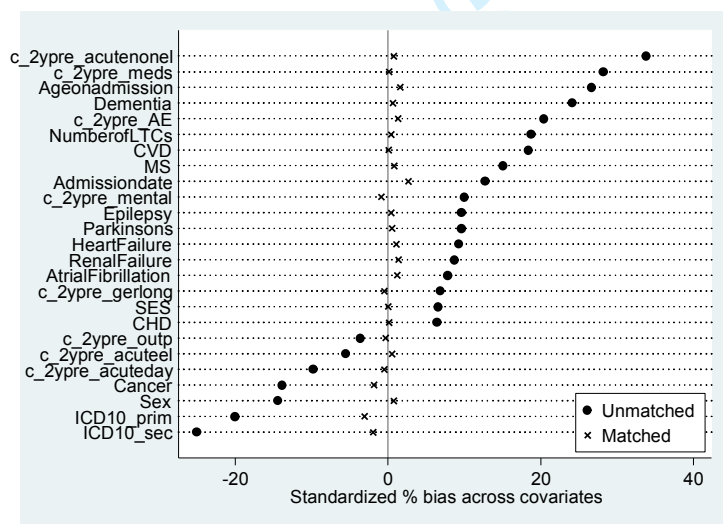
Standardised percentage bias before and after local linear regression propensity score matching for survival in site one



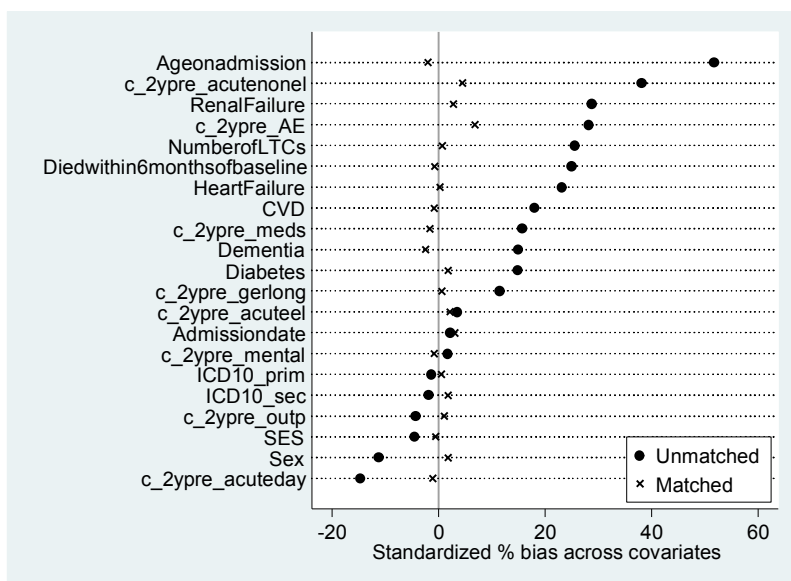
Standardised percentage bias before and after Kernel propensity score matching for costs in site two



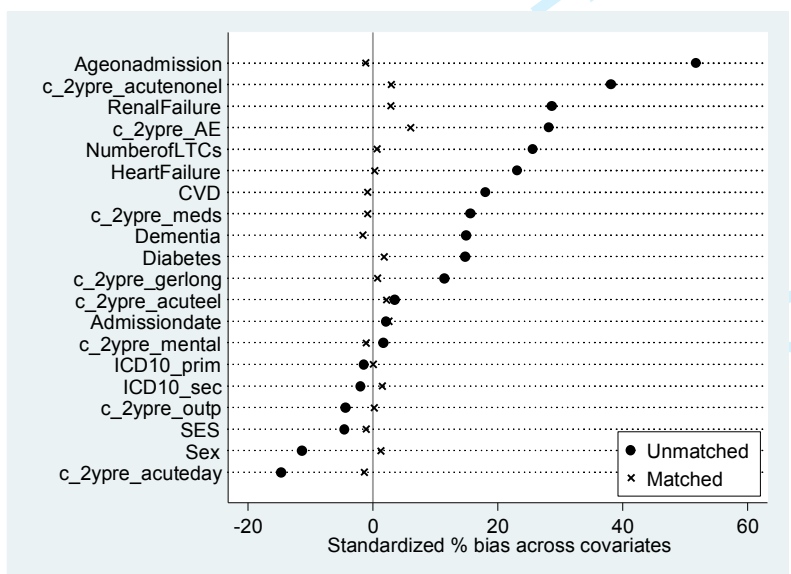
Standardised percentage bias before and after Kernel propensity score matching for survival in site two



Standardised percentage bias before and after local linear regression propensity score matching for costs in site three

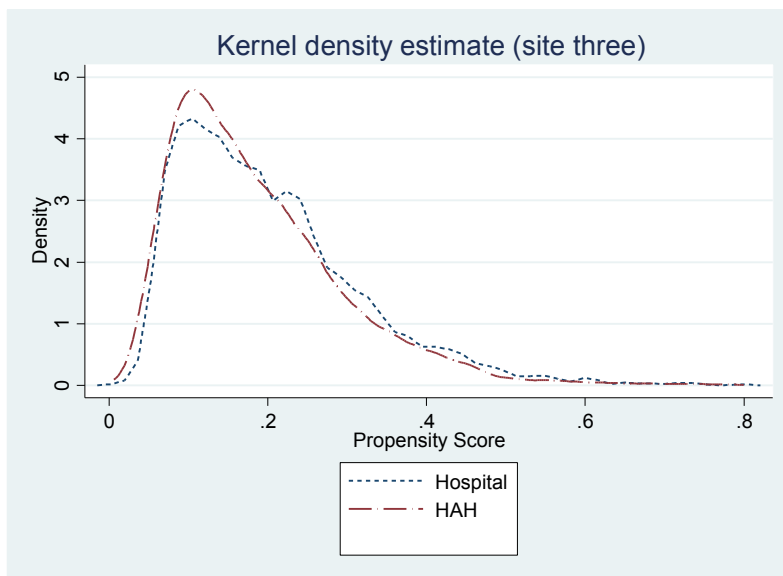
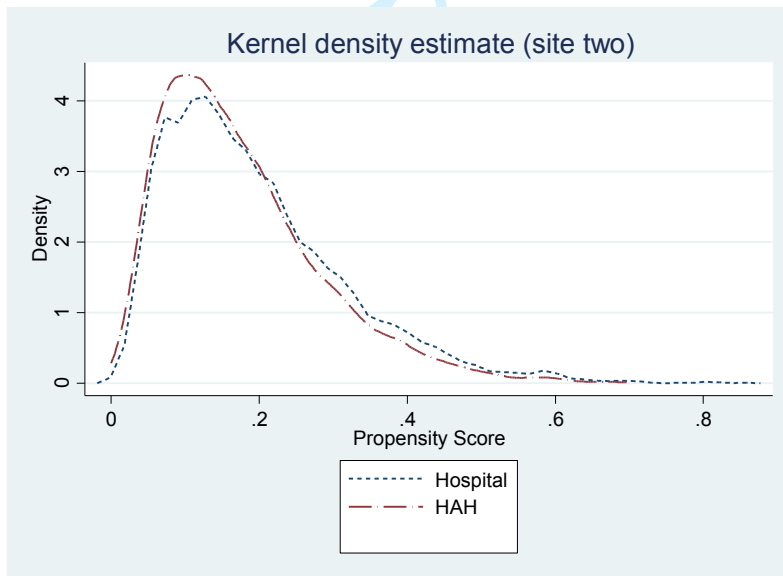
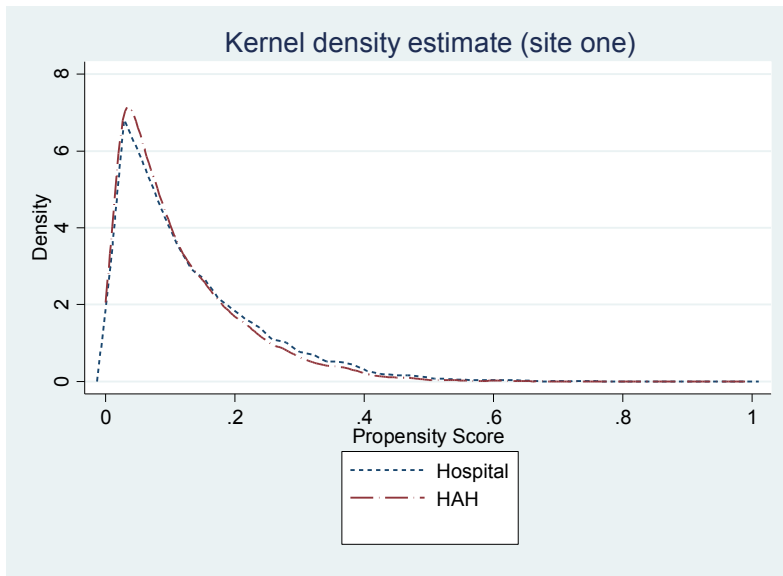


Standardised percentage bias before and after local linear regression propensity score matching for survival in site three



1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

Propensity score distributions by cohort in each site



## Patient characteristics at index admission after propensity score matching

Variable	Site one		Site two		Site three	
	Control	HAH	Control	HAH	Control	HAH
Mean age on admission (sd)	81.2 (7.95)	81.2 (7.20)	82.2 (8.03)	82.4 (7.68)	81.6 (7.96)	81.4 (7.10)
Female	63%	63%	62%	62%	62%	61%
Higher than 4 on the SIMD	35%	35%	53%	52%	44%	44%
More than 4 chronic conditions	44%	45%	48%	50%	43%	43%
Arthritis	29%	29%	38%	38%	33%	36%
Asthma	10%	11%	13%	14%	9%	11%
Atrial fibrillation	29%	28%	32%	33%	30%	29%
Cancer	28%	28%	28%	27%	30%	28%
CVD	27%	27%	26%	26%	27%	26%
Liver disease	3%	3%	4%	4%	4%	5%
COPD	27%	29%	26%	28%	26%	30%
Dementia	26%	25%	26%	26%	18%	17%
Diabetes	23%	23%	23%	24%	26%	26%
Epilepsy	4%	4%	5%	5%	2%	2%
CHD	42%	42%	40%	40%	37%	32%
Heart failure	23%	23%	22%	23%	25%	25%
MS	0%	0%	1%	1%	1%	1%
Parkinson's	4%	4%	3%	3%	3%	5%
Renal failure	22%	23%	24%	24%	25%	25%
Congenital problems	2%	2%	4%	4%	2%	2%
Diseases of blood	32%	32%	30%	27%	29%	29%
Endocrine metabolic disease	36%	36%	46%	45%	39%	35%
Disease of digestive system	70%	72%	70%	70%	64%	66%

HAH: hospital-at-home; SIMD ranges from 1 (most deprived) to 10 (most affluent); Note: a patient could be registered with more than one ICD-10 codes

## Appendix 3. Full results of the regression analyses

## Association of hospital at home with total costs (after propensity score matching)

	site one (n=13,267)		site two (n=4,769)		site three (n=2110)	
	Follow-up period coefficient (se) [95%CI] p value	6 months after discharge coefficient (se) [95%CI] p value	Follow-up period coefficient (se) [95%CI] p value	6 months after discharge coefficient (se) [95%CI] p value	Follow-up period coefficient (se) [95%CI] p value	6 months after discharge coefficient (se) [95%CI] p value
HAH	0.82 (0.03) [0.76;0.89] <0.001	1.27 (0.07) [1.14;1.41] <0.001	1.00 (0.05) [0.92;1.09] 0.982	1.09 (0.07) [0.95;1.24] 0.219	1.15 (0.09) [0.99;1.33] 0.073	1.70 (0.17) [1.4;2.07] <0.001
Admission date	1.00 (0.00) [1.00;1.00] 0.058	1.00 (0.00) [1.00;1.00] 0.009	1.00 (0.00) [1.00;1.00] 0.386	1.00 (0.00) [1.00;1.00] 0.824	1.00 (0.00) [1.00;1.00] 0.009	1.00 (0.00) [1.00;1.00] 0.056
ICD10 primary	1.00 (0.00) [1.00;1.00] 0.660	1.00 (0.00) [1.00;1.00] 0.230	1.00 (0.00) [1.00;1.00] 0.001	1.00 (0.00) [1.00;1.00] <0.001	1.00 (0.00) [1.00;1.00] 0.162	1.00 (0.00) [1.00;1.00] 0.101
ICD10 secondary	1.00 (0.00) [1.00;1.00] 0.641	1.00 (0.00) [1.00;1.00] 0.988	1.00 (0.00) [1.00;1.00] 0.146	1.00 (0.00) [1.00;1.00] 0.238	1.00 (0.00) [1.00;1.00] 0.897	1.00 (0.00) [1.00;1.00] 0.971
2yrs pre AE costs	1.00 (0.00) [1.00;1.00] 0.240	1.00 (0.00) [1.00;1.00] 0.018	1.00 (0.00) [1.00;1.00] 0.624	1.00 (0.00) [1.00;1.00] 0.309	1.00 (0.00) [1.00;1.00] 0.284	1.00 (0.00) [1.00;1.00] 0.42
2yrs pre elective costs	1.00 (0.00) [1.00;1.00] 0.906	1.00 (0.00) [1.00;1.00] 0.919	1.00 (0.00) [1.00;1.00] 0.588	1.00 (0.00) [1.00;1.00] 0.435	1.00 (0.00) [1.00;1.00] 0.865	1.00 (0.00) [1.00;1.00] 0.931
2yrs pre non-elective costs	1.00 (0.00) [1.00;1.00] <0.001	1.00 (0.00) [1.00;1.00] 0.001	1.00 (0.00) [1.00;1.00] 0.694	1.00 (0.00) [1.00;1.00] 0.697	1.00 (0.00) [1.00;1.00] 0.018	1.00 (0.00) [1.00;1.00] 0.015
2yrs pre day case costs	1.00 (0.00) [1.00;1.00] 0.098	1.00 (0.00) [1.00;1.00] 0.020	1.00 (0.00) [1.00;1.00] 0.005	1.00 (0.00) [1.00;1.00] <0.001	1.00 (0.00) [1.00;1.00] 0.14	1.00 (0.00) [1.00;1.00] 0.100
2yrs pre geriatric ward costs	1.00 (0.00) [1.00;1.00] 0.005	1.00 (0.00) [1.00;1.00] 0.054	1.00 (0.00) [1.00;1.00] 0.001	1.00 (0.00) [1.00;1.00] 0.003	1.00 (0.00) [1.00;1.00] 0.634	1.00 (0.00) [1.00;1.00] 0.342
2yrs pre mental ward costs	1.00 (0.00) [1.00;1.00] 0.880	1.00 (0.00) [1.00;1.00] 0.911	1.00 (0.00) [1.00;1.00] 0.009	1.00 (0.00) [1.00;1.00] 0.014	1.00 (0.00) [1.00;1.00] 0.111	1.00 (0.00) [1.00;1.00] 0.382
2yrs pre outpatient costs	1.00 (0.00) [1.00;1.00] 0.087	1.00 (0.00) [1.00;1.00] 0.056	1.00 (0.00) [1.00;1.00] 0.026	1.00 (0.00) [1.00;1.00] 0.043	1.00 (0.00) [1.00;1.00] 0.683	1.00 (0.00) [1.00;1.00] 0.656
2yrs pre medication costs	1.00 (0.00) [1.00;1.00] 0.798	1.00 (0.00) [1.00;1.00] 0.750	1.00 (0.00) [1.00;1.00] 0.172	1.00 (0.00) [1.00;1.00] 0.369	1.00 (0.00) [1.00;1.00] 0.687	1.00 (0.00) [1.00;1.00] 0.935
Died during follow-up	1.03 (0.04) [0.95;1.11] 0.530	0.91 (0.05) [0.82;1.01] 0.089	1.05 (0.05) [0.96;1.15] 0.302	0.90 (0.06) [0.78;1.05] 0.143	1.06 (0.09) [0.90;1.24] 0.498	0.97 (0.11) [0.78;1.21] 0.784
Number of LTCs	1.09 (0.02) [1.05;1.12] <0.001	1.12 (0.02) [1.07;1.16] <0.001	1.04 (0.02) [1.00;1.07] 0.054	1.06 (0.03) [1.00;1.11] 0.035	1.06 (0.03) [1.01;1.11] 0.017	1.10 (0.03) [1.03;1.17] 0.003
Age on admission	1.00 (0.00) [0.99;1.01] 0.383	1.00 (0.00) [0.99;1.01] 0.981	1.00 (0.00) [0.99;1.01] 0.984	1.00 (0.00) [1.00;1.00] 0.349	1.01 (0.01) [1.00;1.02] 0.045	1.01 (0.01) [0.99;1.02] 0.41
Male	1.09 (0.05) [1.01;1.19] 0.034	1.08 (0.06) [0.97;1.19] 0.136	0.95 (0.05) [0.86;1.05] 0.340	0.99 (0.08) [0.85;1.15] 0.859	0.97 (0.08) [0.83;1.13] 0.709	0.98 (0.10) [0.81;1.2] 0.875
SES	1.00 (0.01) [0.98;1.02] 0.988	1.00 (0.01) [0.98;1.03] 0.741	1.01 (0.01) [1.00;1.03] 0.182	1.03 (0.01) [1.00;1.05] 0.033	1.00 (0.02) [0.97;1.03] 0.899	1.01 (0.02) [0.97;1.05] 0.779
Arthritis	0.96 (0.04) [0.88;1.05] 0.398	0.95 (0.05) [0.85;1.06] 0.346	-----	-----	-----	-----
Atrial Fibrillation	-----	-----	1.09 (0.06) [0.98;1.2] 0.098	1.13 (0.08) [0.97;1.30] 0.113	-----	-----
Cancer	-----	-----	1.04 (0.05) [0.94;1.15] 0.485	1.07 (0.08) [0.92;1.24] 0.403	-----	-----
CVD	1.01 (0.06) [0.91;1.13] 0.767	0.99 (0.07) [0.86;1.13] 0.903	1.08 (0.06) [0.97;1.2] 0.168	1.11 (0.09) [0.95;1.29] 0.199	1.10 (0.11) [0.90;1.34] 0.339	1.07 (0.13) [0.84;1.37] 0.585
Liver disease	1.21 (0.13) [0.98;1.50] 0.074	1.20 (0.14) [0.95;1.51] 0.130	-----	-----	-----	-----
Dementia	1.06 (0.05) [0.97;1.17] 0.179	1.07 (0.07) [0.95;1.21] 0.236	1.00 (0.05) [0.91;1.11] 0.942	1.03 (0.08) [0.89;1.19] 0.683	1.14 (0.11) [0.95;1.38] 0.166	1.17 (0.15) [0.91;1.5] 0.211
Epilepsy	-----	-----	1.04 (0.11) [0.85;1.27] 0.734	1.04 (0.15) [0.78;1.38] 0.803	-----	-----
CHD	0.85 (0.05) [0.77;0.95] 0.004	0.83 (0.06) [0.73;0.95] 0.008	1.01 (0.06) [0.9;1.13] 0.871	1.02 (0.08) [0.88;1.20] 0.766	-----	-----
Heart Failure	1.09 (0.06) [0.98;1.20] 0.102	1.10 (0.07) [0.97;1.24] 0.154	1.08 (0.06) [0.96;1.21] 0.186	1.08 (0.09) [0.92;1.28] 0.363	1.01 (0.10) [0.83;1.23] 0.919	0.98 (0.13) [0.76;1.26] 0.879
Multiple sclerosis	-----	-----	0.74 (0.10) [0.57;0.98] 0.033	0.59 (0.15) [0.36;0.97] 0.035	-----	-----
Parkinson's	1.24 (0.11) [1.03;1.48] 0.019	1.20 (0.14) [0.95;1.51] 0.120	1.09 (0.15) [0.83;1.42] 0.554	1.09 (0.20) [0.75;1.57] 0.664	-----	-----
Renal Failure	1.03 (0.05) [0.94;1.13] 0.513	1.06 (0.06) [0.94;1.19] 0.362	1.05 (0.06) [0.94;1.17] 0.420	1.08 (0.09) [0.92;1.26] 0.348	1.12 (0.12) [0.9;1.38] 0.306	1.14 (0.16) [0.87;1.49] 0.346
Diseases of blood	1.05 (0.05) [0.96;1.15] 0.275	1.05 (0.06) [0.94;1.18] 0.363	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	1.21 (0.11) [1.01;1.45] 0.043	1.24 (0.14) [0.99;1.55] 0.061
Constant	15.93 (46.90) [0.05;5098.92] 0.347	0.19 (0.68) [0.00;224.04] 0.644	285486.5 (1267507) [47.47; 1.72E+09] 0.005	899.53 (5743.23) [0.00;0.00] 0.287	20700000000000 (186000000000000) [500612.1;8.6E+20] 0.001	22300000000000 (25100000000000) [559.85;8.85E+21] 0.012

# driven mainly by non-elective hospital care; Note the HAH unit costs in site one were £628.34 per admission to HAH and have been added to the costs during the episode.

## Association of hospital-at-home with mortality risk during study period (after propensity score matching)

	site one (n=13,267)				site two (n=4,771)				site three (n=2110)			
	coefficient	(se)	[95%CI]	p value	coefficient	(se)	[95%CI]	p value	coefficient	(se)	[95%CI]	p value
HAH	1.09	(0.05)	[1.00;1.19]	0.059	1.29	(0.07)	[1.15;1.44]	<0.0010	1.27	(0.12)	[1.06;1.54]	0.011
Admission date	1.00	(0.00)	[1.00;1.00]	0.842	1.00	(0.00)	[1.00;1.00]	0.100	1	(0)	[1;1]	0.687
ICD10 primary	1.00	(0.00)	[1.00;1.00]	<0.001	1.00	(0.00)	[1.00;1.00]	0.001	1	(0)	[1;1]	0.006
ICD10 secondary	1.00	(0.00)	[1.00;1.00]	<0.001	1.00	(0.00)	[1.00;1.00]	0.023	1	(0)	[1;1]	0.359
2yrs pre AE costs	1.00	(0.00)	[1.00;1.00]	0.640	1.00	(0.00)	[1.00;1.00]	0.153	1	(0)	[1;1]	0.027
2yrs pre elective costs	1.00	(0.00)	[1.00;1.00]	0.487	1.00	(0.00)	[1.00;1.00]	0.462	1	(0)	[1;1]	0.079
2yrs pre non-elective costs	1.00	(0.00)	[1.00;1.00]	0.001	1.00	(0.00)	[1.00;1.00]	0.007	1	(0)	[1;1]	0.052
2yrs pre day case costs	1.00	(0.00)	[1.00;1.00]	<0.001	1.00	(0.00)	[1.00;1.00]	0.001	1	(0)	[1;1]	0.903
2yrs pre geriatric ward costs	1.00	(0.00)	[1.00;1.00]	0.022	1.00	(0.00)	[1.00;1.00]	<0.001	1	(0)	[1;1]	0.338
2yrs pre mental ward costs	1.00	(0.00)	[1.00;1.00]	0.419	1.00	(0.00)	[1.00;1.00]	0.943	1	(0)	[1;1]	0
2yrs pre outpatient costs	1.00	(0.00)	[1.00;1.00]	0.091	1.00	(0.00)	[1.00;1.00]	0.882	1	(0)	[1;1]	0.001
2yrs pre medication costs	1.00	(0.00)	[1.00;1.00]	0.044	1.00	(0.00)	[1.00;1.00]	0.037	1	(0)	[1;1]	0
Number of LTCs	1.03	(0.02)	[0.99;1.07]	0.120	0.96	(0.02)	[0.92;1.01]	0.107	1.07	(0.04)	[1;1.14]	0.048
Age on admission	1.04	(0)	[1.03;1.04]	<0.001	1.03	(0.00)	[1.02;1.04]	<0.001	1.04	(0.01)	[1.02;1.05]	0
Male	1.12	(0.05)	[1.01;1.22]	0.017	1.23	(0.08)	[1.09;1.39]	0.001	1.37	(0.14)	[1.12;1.67]	0.002
SES	0.97	(0.01)	[0.95;0.99]	0.001	0.98	(0.01)	[0.96;1.00]	0.088	1.01	(0.02)	[0.98;1.05]	0.483
Arthritis	0.86	(0.05)	[0.77;0.97]	0.008	-----	-----	-----	-----	-----	-----	-----	-----
Atrial Fibrillation	-----	-----	-----	-----	1.11	(0.08)	[0.97;1.28]	0.133	-----	-----	-----	-----
Cancer	-----	-----	-----	-----	1.86	(0.12)	[1.64;2.11]	<0.001	-----	-----	-----	-----
CVD	0.94	(0.06)	[0.83;1.05]	0.276	1.06	(0.08)	[0.92;1.22]	0.438	0.95	(0.12)	[0.74;1.21]	0.673
Liver disease	1.33	(0.16)	[1.04;1.67]	0.015	-----	-----	-----	-----	-----	-----	-----	-----
Dementia	1.11	(0.06)	[1.00;1.25]	0.058	1.59	(0.11)	[1.39;1.82]	<0.001	1.31	(0.16)	[1.03;1.67]	0.025
Epilepsy	-----	-----	-----	-----	1.19	(0.17)	[0.91;1.57]	0.207	-----	-----	-----	-----
CHD	0.91	(0.05)	[0.82;1.03]	0.114	0.93	(0.07)	[0.80;1.08]	0.345	-----	-----	-----	-----
Heart Failure	1.13	(0.07)	[1.00;1.28]	0.052	1.35	(0.11)	[1.15;1.57]	<0.001	1.16	(0.15)	[0.9;1.5]	0.256
Multiple sclerosis	-----	-----	-----	-----	1.54	(0.39)	[0.94;2.52]	0.086	-----	-----	-----	-----
Parkinson's	1.11	(0.13)	[0.86;1.39]	0.374	0.93	(0.17)	[0.65;1.33]	0.678	-----	-----	-----	-----
Renal Failure	1.07	(0.07)	[0.95;1.21]	0.292	1.35	(0.10)	[1.16;1.56]	<0.001	0.93	(0.12)	[0.72;1.2]	0.571
Diseases of blood	0.93	(0.05)	[0.85;1.06]	0.201	-----	-----	-----	-----	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	-----	-----	-----	-----	0.74	(0.1)	[0.57;0.97]	0.026
Constant	0.01	(0.04)	[0.00;7.06]	0.174	0.00	(0.00)	[0.00;0.18]	0.025	0	(0)	[0;319640.8]	0.405



## Results of the subgroup analysis including only patients with dementia (costs)

	site one (n=2,321)		site two (n=1,053)		site three (n=280)	
	Follow-up period	Total costs in 6 months after discharge	Follow-up period	Total costs in 6 months after discharge	Follow-up period	Total costs in 6 months after discharge
	coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value	coefficient (se) [95%CI] p value
HAH (hospital)	0.76 (0.05) [0.66;0.87] 0	1.18 (0.11) [0.99;1.41] 0.071	0.76 (0.06) [0.66;0.88] 0	0.75 (0.09) [0.59;0.96] 0.021	0.87 (0.15) [0.63;1.21] 0.409	1.58 (0.41) [0.95;2.63] 0.078
Admission date	1 (0) [1;1] 0.528	1.00 (0.00) [1.00;1.00] 0.329	1 (0) [1;1] 0.513	1.00 (0.00) [1.00;1.00] 0.532	1 (0) [1;1] 0.002	1 (0) [0.99;1] 0.003
ICD10 primary	1 (0) [1;1] 0.025	1.00 (0.00) [1.00;1.00] 0.003	1 (0) [1;1] 0.079	1.00 (0.00) [1.00;1.00] 0.008	1 (0) [1;1] 0.666	1 (0) [1;1] 0.123
ICD10 secondary	1 (0) [1;1] 0.027	1.00 (0.00) [1.00;1.00] 0.086	-----	-----	1 (0) [1;1] 0.946	1 (0) [1;1] 0.594
2yrs pre AE costs	1 (0) [1;1] 0.063	1.00 (0.00) [1.00;1.00] 0.021	1 (0) [1;1] 0.979	1.00 (0.00) [1.00;1.00] 0.93	1 (0) [1;1] 0.57	1 (0) [1;1] 0.331
2yrs pre elective costs	1 (0) [1;1] 0.913	1.00 (0.00) [1.00;1.00] 0.708	1 (0) [1;1] 0.979	1.00 (0.00) [1.00;1.00] 0.889	1 (0) [1;1] 0.115	1 (0) [1;1] 0.208
2yrs pre non-elective costs	1 (0) [1;1] 0.564	1.00 (0.00) [1.00;1.00] 0.605	1 (0) [1;1] 0.031	1.00 (0.00) [1.00;1.00] 0.008	1 (0) [1;1] 0.888	1 (0) [1;1] 0.639
2yrs pre day case costs	1 (0) [1;1] 0.455	1.00 (0.00) [1.00;1.00] 0.632	1 (0) [1;1] 0.725	1.00 (0.00) [1.00;1.00] 0.307	1 (0) [1;1] 0.1	1 (0) [1;1] 0.279
2yrs pre geriatric ward costs	1 (0) [1;1] 0.233	1.00 (0.00) [1.00;1.00] 0.566	1 (0) [1;1] 0.012	1.00 (0.00) [1.00;1.00] 0.003	1 (0) [1;1] 0.907	1 (0) [1;1] 0.952
2yrs pre mental ward costs	1 (0) [1;1] 0.343	1.00 (0.00) [1.00;1.00] 0.335	1 (0) [1;1] 0.084	1.00 (0.00) [1.00;1.00] 0.042	1 (0) [1;1] 0.01	1 (0) [1;1] 0.021
2yrs pre outpatient costs	1 (0) [1;1] 0.066	1.00 (0.00) [1.00;1.00] 0.082	1 (0) [1;1] 0.001	1.00 (0.00) [1.00;1.00] 0.001	1 (0) [1;1] 0.685	1 (0) [1;1] 0.403
2yrs pre medication costs	1 (0) [1;1] 0.306	1.00 (0.00) [1.00;1.00] 0.316	1 (0) [1;1] 0.13	1.00 (0.00) [1.00;1.00] 0.265	1 (0) [1;1] 0.042	1 (0) [1;1] 0.044
Died within 6months	0.81 (0.06) [0.7;0.94] 0.005	0.70 (0.07) [0.58;0.85] <0.001	0.89 (0.07) [0.76;1.03] 0.118	0.73 (0.09) [0.58;0.93] 0.011	0.66 (0.13) [0.45;0.96] 0.031	0.44 (0.13) [0.25;0.77] 0.004
Number of LTCs	1.06 (0.03) [1;1.12] 0.069	1.07 (0.04) [1.00;1.16] 0.063	1.08 (0.03) [1.02;1.14] 0.006	1.15 (0.05) [1.05;1.26] 0.003	1.04 (0.06) [0.94;1.16] 0.443	1.01 (0.08) [0.86;1.18] 0.935
Age on admission	0.99 (0.01) [0.98;1] 0.094	0.98 (0.01) [0.97;1.00] 0.015	0.98 (0.01) [0.97;1] 0.007	0.97 (0.01) [0.95;0.99] 0.003	1 (0.01) [0.98;1.03] 0.933	1 (0.02) [0.97;1.03] 0.946
Male	1.13 (0.08) [0.99;1.31] 0.076	1.14 (0.11) [0.95;1.37] 0.151	0.95 (0.07) [0.82;1.11] 0.511	0.95 (0.12) [0.74;1.22] 0.679	1.05 (0.17) [0.76;1.43] 0.78	1.07 (0.26) [0.67;1.71] 0.774
SES	1.01 (0.01) [0.98;1.04] 0.693	1.01 (0.02) [0.97;1.04] 0.77	1.03 (0.01) [1;1.05] 0.053	1.06 (0.02) [1.01;1.10] 0.010	1.03 (0.03) [0.97;1.09] 0.3	1.04 (0.04) [0.96;1.12] 0.3
Atrial Fibrillation	-----	-----	1.03 (0.09) [0.87;1.23] 0.722	1.00 (0.14) [0.77;1.31] 0.986	-----	-----
Arthritis	1.02 (0.09) [0.86;1.2] 0.833	1.02 (0.11) [0.83;1.25] 0.862	-----	-----	-----	-----
Cancer	-----	-----	1.04 (0.1) [0.87;1.24] 0.679	1.06 (0.16) [0.79;1.43] 0.688	-----	-----
CVD	0.92 (0.07) [0.78;1.08] 0.3	0.91 (0.1) [0.74;1.12] 0.374	0.98 (0.08) [0.83;1.16] 0.845	0.95 (0.14) [0.72;1.26] 0.741	1.39 (0.28) [0.94;2.06] 0.103	1.65 (0.48) [0.93;2.91] 0.085
Liver disease	0.8 (0.12) [0.59;1.08] 0.138	0.8 (0.16) [0.54;1.20] 0.286	-----	-----	-----	-----
CHD	1.01 (0.09) [0.85;1.2] 0.917	1.05 (0.12) [0.84;1.30] 0.688	0.94 (0.09) [0.78;1.12] 0.482	0.98 (0.14) [0.74;1.30] 0.891	-----	-----
Epilepsy	-----	-----	0.97 (0.15) [0.72;1.3] 0.842	0.78 (0.16) [0.53;1.16] 0.221	-----	-----
Heart Failure	1.03 (0.11) [0.83;1.27] 0.818	1.02 (0.14) [0.79;1.33] 0.878	0.92 (0.11) [0.73;1.15] 0.452	0.90 (0.17) [0.62;1.29] 0.558	0.83 (0.19) [0.53;1.3] 0.409	1.16 (0.42) [0.57;2.37] 0.687
Multiple sclerosis	-----	-----	0.4 (0.06) [0.29;0.54] 0	0.18 (0.07) [0.09;0.37] <0.001	-----	-----
Parkinson's	1.13 (0.15) [0.88;1.46] 0.333	1.00 (0.17) [0.72;1.39] 0.992	0.87 (0.14) [0.63;1.18] 0.365	0.68 (0.20) [0.39;1.20] 0.188	-----	-----
Renal Failure	1.03 (0.1) [0.85;1.24] 0.769	1.12 (0.14) [0.88;1.42] 0.354	0.9 (0.09) [0.75;1.09] 0.296	0.82 (0.13) [0.60;1.12] 0.203	1.2 (0.24) [0.81;1.78] 0.354	1.25 (0.35) [0.72;2.17] 0.435
Diseases of blood	0.93 (0.08) [0.79;1.11] 0.437	0.90 (0.1) [0.73;1.11] 0.337	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	0.85 (0.18) [0.55;1.3] 0.449	0.92 (0.26) [0.52;1.6] 0.756
Constant	469.5 (2319.98) [0.03;7547051] 0.213	22.71 (140.52) [0;4194325] 0.614	2796754 (19900000) [2.38;3290000000000] 0.037	40500000 (472000000) [0;32900000000000000] 0.132	2.82E+29 (5.36E+30) [18000000000000;4.43E+45] 0	3.34E+38 (9.1E+39) [210000000000000;5.29E+61] 0.001

## Results of the subgroup analysis including only patients with dementia (mortality risk)

	site one (n=2,321)	site two (n=1,053)	site three (n=280)
	Mortality rate during follow-up coefficient (se) [95%CI] p value	Mortality rate during follow-up coefficient (se) [95%CI] p value	Mortality rate during follow-up coefficient (se) [95%CI] p value
HAH (hospital)	1.05 (0.09) [0.89;1.24] 0.594	1.41 (0.12) [1.19;1.67] <0.001	1.65 (0.32) [1.12;2.41] 0.011
Admission date	1.00 (0.00) [1.00;1.00] 0.19	1.00 (0.00) [1.00;1.00] 0.001	1 (0) [1;1] 0.788
ICD10 primary	1.00 (0.00) [1.00;1.00] <0.001	1.00 (0.00) [1.00;1.00] 0.001	1 (0) [1;1] 0.14
ICD10 secondary	1.00 (0.00) [1.00;1.00] 0.207	-----	1 (0) [1;1] 0.979
2yrs pre AE costs	1.00 (0.00) [1.00;1.00] 0.251	1.00 (0.00) [1.00;1.00] 0.609	1 (0) [1;1] 0.029
2yrs pre elective costs	1.00 (0.00) [1.00;1.00] 0.735	1.00 (0.00) [1.00;1.00] 0.129	1 (0) [1;1] 0.554
2yrs pre non-elective costs	1.00 (0.00) [1.00;1.00] 0.173	1.00 (0.00) [1.00;1.00] 0.484	1 (0) [1;1] 0.814
2yrs pre day case costs	1.00 (0.00) [1.00;1.00] 0.088	1.00 (0.00) [1.00;1.00] 0.004	1 (0) [1;1] 0.896
2yrs pre geriatric ward costs	1.00 (0.00) [1.00;1.00] 0.644	1.00 (0.00) [1.00;1.00] <0.001	1 (0) [1;1] 0.783
2yrs pre mental ward costs	1.00 (0.00) [1.00;1.00] 0.569	1.00 (0.00) [1.00;1.00] 0.112	1 (0) [1;1] 0
2yrs pre outpatient costs	1.00 (0.00) [1.00;1.00] 0.070	1.00 (0.00) [1.00;1.00] 0.167	1 (0) [1;1] 0
2yrs pre medication costs	1.00 (0.00) [1.00;1.00] 0.004	1.00 (0.00) [1.00;1.00] 0.156	1 (0) [1;1] 0.011
Died within 6months	-----	-----	-----
Number of LTCs	0.94 (0.03) [0.88;1.01] 0.113	0.95 (0.03) [0.89;1.01] 0.115	0.98 (0.07) [0.86;1.13] 0.827
Age on admission	1.04 (0.01) [1.02;1.05] <0.001	1.03 (0.01) [1.01;1.04] <0.001	1.04 (0.02) [1;1.07] 0.024
Male	1.19 (0.11) [0.99;1.42] 0.063	1.17 (0.10) [0.99;1.38] 0.070	1.18 (0.25) [0.78;1.79] 0.43
SES	0.97 (0.02) [0.94;1.01] 0.134	1.00 (0.02) [0.97;1.03] 0.991	0.96 (0.04) [0.88;1.04] 0.3
Atrial Fibrillation	-----	1.03 (0.11) [0.85;1.26] 0.75	-----
Arthritis	1.06 (0.11) [0.86;1.30] 0.600	-----	-----
Cancer	-----	1.40 (0.13) [1.16;1.68] <0.001	-----
CVD	1.55 (0.41) [0.92;2.61] 0.099	1.14 (0.11) [0.94;1.39] 0.176	1.02 (0.25) [0.63;1.65] 0.925
Liver disease	0.98 (0.11) [0.79;1.21] 0.845	-----	-----
CHD	1.21 (0.16) [0.94;1.56] 0.135	0.99 (0.10) [0.81;1.20] 0.885	-----
Epilepsy	-----	1.26 (0.19) [0.94;1.70] 0.120	-----
Heart Failure	1.21 (0.16) [0.94;1.56] 0.135	1.33 (0.17) [1.04;1.70] 0.023	1.88 (0.49) [1.12;3.14] 0.017
Multiple sclerosis	-----	0.96 (0.51) [0.34;2.72] 0.932	-----
Parkinson's	1.26 (0.22) [0.9;1.78] 0.180	1.04 (0.20) [0.71;1.51] 0.848	-----
Renal Failure	1.06 (0.12) [0.84;1.32] 0.637	1.15 (0.12) [0.93;1.41] 0.192	0.56 (0.16) [0.32;0.97] 0.037
Diseases of blood	0.96 (0.11) [0.77;1.19] 0.709	-----	-----
Diabetes	-----	-----	0.6 (0.2) [0.32;1.15] 0.123
Constant	0.00 (0.00) [0.00;1.37] 0.057	0.00 (0.00) [0.00;0.00] <0.001	0 (0) [0;1810000000000000] 0.652

## Results of the subgroup analysis excluding those who had died

	site one (n=10,132)		site two (n=3,584)		site three (n=1691)	
	Follow-up period coefficient (se) [95%CI] p value	Total costs in 6 months after discharge coefficient (se) [95%CI] p value	Follow-up period coefficient (se) [95%CI] p value	Total costs in 6 months after discharge coefficient (se) [95%CI] p value	Follow-up period coefficient (se) [95%CI] p value	Total costs in 6 months after discharge coefficient (se) [95%CI] p value
HAH (hospital)	0.85 (0.04) [0.77;0.94] 0.002	1.23 (0.08) [1.08;1.4] 0.002	1.11 (0.06) [1;1.25] 0.058	1.17 (0.10) [0.99;1.38] 0.070	1.20 (0.11) [1;1.43] 0.046	1.71 (0.20) [1.36;2.15] <0.001
Admission date	1 (0) [1;1] 0.076	1.00 (0.00) [1.00;1.00] 0.032	1 (0) [1;1] 0.833	1.00 (0.00) [1.00;1.00] 0.337	1 (0) [1;1] 0.075	1 (0) [1;1] 0.282
ICD10 primary	1 (0) [1;1] 0.692	1.00 (0.00) [1.00;1.00] 0.993	1 (0) [1;1] 0.126	1.00 (0.00) [1.00;1.00] 0.038	1 (0) [1;1] 0.282	1 (0) [1;1] 0.279
ICD10 secondary	1 (0) [1;1] 0.817	1.00 (0.00) [1.00;1.00] 0.473	1 (0) [1;1] 0.014	1.00 (0.00) [1.00;1.00] 0.024	1 (0) [1;1] 0.724	1 (0) [1;1] 0.801
2yrs pre AE costs	1 (0) [1;1] 0.08	1.00 (0.00) [1.00;1.00] 0.012	1 (0) [1;1] 0.461	1.00 (0.00) [1.00;1.00] 0.135	1 (0) [1;1] 0.435	1 (0) [1;1] 0.761
2yrs pre elective costs	1 (0) [1;1] 0.015	1.00 (0.00) [1.00;1.00] 0.046	1 (0) [1;1] 0.576	1.00 (0.00) [1.00;1.00] 0.429	1 (0) [1;1] 0.63	1 (0) [1;1] 0.725
2yrs pre non-elective costs	1 (0) [1;1] 0	1.00 (0.00) [1.00;1.00] <0.001	1 (0) [1;1] 0.651	1.00 (0.00) [1.00;1.00] 0.700	1 (0) [1;1] 0.199	1 (0) [1;1] 0.01
2yrs pre day case costs	1 (0) [1;1] 0.416	1.00 (0.00) [1.00;1.00] 0.158	1 (0) [1;1] 0.057	1.00 (0.00) [1.00;1.00] 0.023	1 (0) [1;1] 0.068	1 (0) [1;1] 0.064
2yrs pre geriatric ward costs	1 (0) [1;1] 0.031	1.00 (0.00) [1.00;1.00] 0.029	1 (0) [1;1] 0.625	1.00 (0.00) [1.00;1.00] 0.806	1 (0) [1;1] 0.484	1 (0) [1;1] 0.103
2yrs pre mental ward costs	1 (0) [1;1] 0.206	1.00 (0.00) [1.00;1.00] 0.166	1 (0) [1;1] 0.009	1.00 (0.00) [1.00;1.00] 0.020	1 (0) [1;1] 0.01	1 (0) [1;1] 0.004
2yrs pre outpatient costs	1 (0) [1;1] 0.236	1.00 (0.00) [1.00;1.00] 0.187	1 (0) [1;1] 0.748	1.00 (0.00) [1.00;1.00] 0.802	1 (0) [1;1] 0.798	1 (0) [1;1] 0.908
2yrs pre medication costs	1 (0) [1;1] 0.399	1.00 (0.00) [1.00;1.00] 0.383	1 (0) [1;1] 0.011	1.00 (0.00) [1.00;1.00] 0.016	1 (0) [1;1] 0.37	1 (0) [1;1] 0.77
Number of LTCs	1.08 (0.02) [1.04;1.12] 0	1.12 (0.03) [1.07;1.18] <0.001	1.03 (0.02) [0.99;1.08] 0.169	1.06 (0.04) [0.99;1.13] 0.076	1.06 (0.03) [1.01;1.13] 0.032	1.09 (0.04) [1.01;1.17] 0.026
Age on admission	1.01 (0) [1;1.01] 0.025	1.01 (0.00) [1.00;1.02] 0.048	1.01 (0) [1;1.01] 0.054	1.01 (0.01) [1.00;1.02] 0.254	1.02 (0.01) [1;1.03] 0.019	1.01 (0.01) [0.99;1.03] 0.171
Male	1.11 (0.06) [1;1.22] 0.051	1.12 (0.07) [0.99;1.26] 0.085	0.94 (0.06) [0.83;1.07] 0.353	0.97 (0.09) [0.80;1.17] 0.752	0.97 (0.09) [0.8;1.16] 0.716	1 (0.12) [0.79;1.26] 0.974
SES	1 (0.01) [0.98;1.02] 0.965	1 (0.01) [0.98;1.03] 0.778	1.02 (0.01) [1;1.04] 0.081	1.03 (0.01) [1.00;1.06] 0.023	1 (0.02) [0.96;1.03] 0.822	1 (0.02) [0.95;1.05] 0.951
Atrial Fibrillation	-----	-----	1.07 (0.07) [0.94;1.21] 0.305	1.09 (0.10) [0.92;1.29] 0.335	-----	-----
Arthritis	0.99 (0.05) [0.89;1.1] 0.889	0.96 (0.06) [0.85;1.1] 0.584	-----	-----	-----	-----
Cancer	-----	-----	1 (0.07) [0.88;1.15] 0.961	1.01 (0.10) [0.84;1.23] 0.899	-----	-----
CVD	1.04 (0.07) [0.91;1.2] 0.552	1.00 (0.09) [0.85;1.19] 0.956	1.14 (0.08) [1;1.3] 0.058	1.14 (0.11) [0.95;1.36] 0.174	1.12 (0.14) [0.88;1.43] 0.367	1.1 (0.17) [0.81;1.5] 0.531
Liver disease	1.35 (0.2) [1.01;1.8] 0.045	1.31 (0.21) [0.95;1.81] 0.097	-----	-----	-----	-----
Dementia	1.16 (0.07) [1.04;1.3] 0.009	1.17 (0.08) [1.01;1.35] 0.033	1.08 (0.07) [0.96;1.22] 0.195	1.11 (0.10) [0.93;1.31] 0.244	1.37 (0.16) [1.09;1.73] 0.008	1.49 (0.23) [1.09;2.02] 0.011
CHD	0.82 (0.06) [0.72;0.94] 0.004	0.79 (0.07) [0.67;0.93] 0.004	1.01 (0.07) [0.87;1.16] 0.941	1.03 (0.10) [0.85;1.24] 0.799	-----	-----
Epilepsy	-----	-----	1.08 (0.12) [0.86;1.35] 0.518	1.09 (0.17) [0.80;1.48] 0.581	-----	-----
Heart Failure	1.1 (0.07) [0.97;1.25] 0.131	1.08 (0.08) [0.93;1.26] 0.293	1.08 (0.08) [0.94;1.24] 0.287	1.07 (0.11) [0.88;1.31] 0.491	1.05 (0.13) [0.82;1.34] 0.719	1.01 (0.16) [0.74;1.39] 0.932
Multiple sclerosis	-----	-----	0.72 (0.14) [0.49;1.06] 0.095	0.66 (0.21) [0.35;1.25] 0.202	-----	-----
Parkinson's	1.19 (0.1) [1;1.41] 0.05	1.15 (0.13) [0.93;1.43] 0.19	1.22 (0.18) [0.91;1.64] 0.193	1.34 (0.27) [0.91;1.98] 0.139	-----	-----
Renal Failure	1.01 (0.06) [0.89;1.14] 0.911	1.00 (0.07) [0.87;1.16] 0.949	1.06 (0.08) [0.92;1.22] 0.443	1.06 (0.11) [0.86;1.29] 0.602	1.12 (0.15) [0.86;1.46] 0.411	1.19 (0.2) [0.85;1.66] 0.317
Diseases of blood	1.04 (0.06) [0.94;1.16] 0.414	1.04 (0.07) [0.92;1.19] 0.516	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	1.33 (0.15) [1.07;1.65] 0.01	1.37 (0.19) [1.04;1.81] 0.026
Constant	3.67 (13.85) [0;5959] 0.73	0.07 (0.31) [0;592.13] 0.558	1064.79 (5943.4) [0.02;60000000] 0.212	0.89 (6.96) [0;4301665] 0.988	10100000000 (105000000000) [149.57;6810000000000000000] 0.015	1320000000 (18000000000) [0;5.67E+20] 0.124

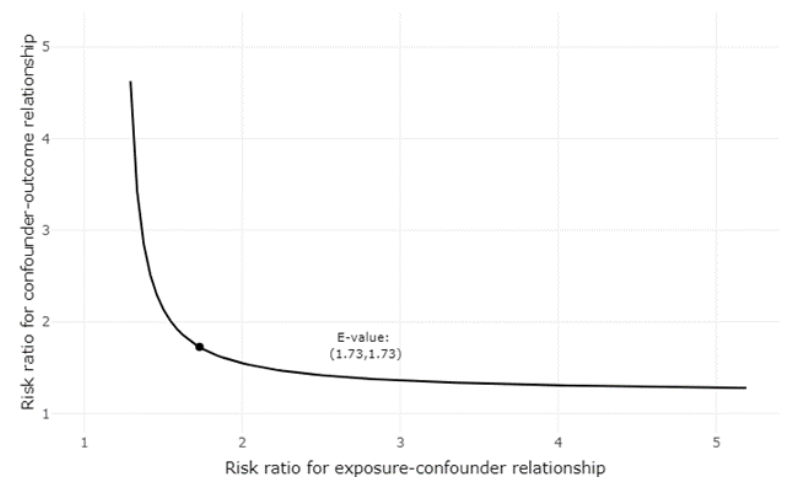
Results of the sensitivity analysis

	site one (n=13,267)		site two (n=4,769)		site three (n=2110)	
	Total costs in follow-up (50% higher HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% lower HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% higher HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% lower HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% higher HAH unit costs) coefficient (se) [95%CI] p value	Total costs in follow-up (50% lower HAH unit costs) coefficient (se) [95%CI] p value
HAH (hospital)	0.87 (0.03) [0.81;0.94] 0.001	0.77 (0.03) [0.71;0.84] 0	1.18 (0.05) [1.09;1.28] 0	0.81 (0.04) [0.74;0.9] 0	1.23 (0.09) [1.07;1.42] 0.004	1.07 (0.09) [0.91;1.25] 0.399
Admission date	1 (0) [1;1] 0.071	1 (0) [1;1] 0.048	1 (0) [1;1] 0.489	1 (0) [1;1] 0.3	1 (0) [1;1] 0.007	1 (0) [1;1] 0.012
ICD10 primary	1 (0) [1;1] 0.649	1 (0) [1;1] 0.671	1 (0) [1;1] 0.001	1 (0) [1;1] 0.001	1 (0) [1;1] 0.167	1 (0) [1;1] 0.16
ICD10 secondary	1 (0) [1;1] 0.588	1 (0) [1;1] 0.701	1 (0) [1;1] 0.148	1 (0) [1;1] 0.145	1 (0) [1;1] 0.875	1 (0) [1;1] 0.909
2yrs pre AE costs	1 (0) [1;1] 0.223	1 (0) [1;1] 0.261	1 (0) [1;1] 0.687	1 (0) [1;1] 0.561	1 (0) [1;1] 0.307	1 (0) [1;1] 0.267
2yrs pre elective costs	1 (0) [1;1] 0.909	1 (0) [1;1] 0.904	1 (0) [1;1] 0.537	1 (0) [1;1] 0.657	1 (0) [1;1] 0.896	1 (0) [1;1] 0.813
2yrs pre non-elective costs	1 (0) [1;1] 0	1 (0) [1;1] 0	1 (0) [1;1] 0.919	1 (0) [1;1] 0.458	1 (0) [1;1] 0.015	1 (0) [1;1] 0.021
2yrs pre day case costs	1 (0) [1;1] 0.099	1 (0) [1;1] 0.097	1 (0) [1;1] 0.006	1 (0) [1;1] 0.004	1 (0) [1;1] 0.131	1 (0) [1;1] 0.148
2yrs pre geriatric ward costs	1 (0) [1;1] 0.006	1 (0) [1;1] 0.005	1 (0) [1;1] 0.002	1 (0) [1;1] 0	1 (0) [1;1] 0.562	1 (0) [1;1] 0.713
2yrs pre mental ward costs	1 (0) [1;1] 0.905	1 (0) [1;1] 0.854	1 (0) [1;1] 0.005	1 (0) [1;1] 0.02	1 (0) [1;1] 0.09	1 (0) [1;1] 0.132
2yrs pre outpatient costs	1 (0) [1;1] 0.086	1 (0) [1;1] 0.088	1 (0) [1;1] 0.027	1 (0) [1;1] 0.026	1 (0) [1;1] 0.699	1 (0) [1;1] 0.675
2yrs pre medication costs	1 (0) [1;1] 0.713	1 (0) [1;1] 0.892	1 (0) [1;1] 0.136	1 (0) [1;1] 0.236	1 (0) [1;1] 0.713	1 (0) [1;1] 0.663
Died within 6months	1.03 (0.04) [0.95;1.11] 0.492	1.02 (0.04) [0.94;1.12] 0.572	1.05 (0.04) [0.97;1.14] 0.252	1.05 (0.05) [0.95;1.16] 0.38	1.06 (0.08) [0.91;1.23] 0.474	1.06 (0.09) [0.89;1.25] 0.517
Number of LTCs	1.08 (0.02) [1.05;1.11] 0	1.09 (0.02) [1.05;1.13] 0	1.04 (0.02) [1;1.07] 0.033	1.04 (0.02) [0.99;1.08] 0.093	1.06 (0.02) [1.01;1.1] 0.016	1.06 (0.03) [1.01;1.11] 0.019
Age on admission	1 (0) [1;1.01] 0.323	1 (0) [1;1.01] 0.452	1 (0) [1;1.01] 0.788	1 (0) [0.99;1.01] 0.789	1.01 (0.01) [1;1.02] 0.037	1.01 (0.01) [1;1.02] 0.055
Male	1.09 (0.04) [1.01;1.18] 0.035	1.1 (0.05) [1.01;1.2] 0.034	0.96 (0.04) [0.88;1.04] 0.311	0.95 (0.06) [0.85;1.07] 0.382	0.97 (0.07) [0.84;1.12] 0.686	0.97 (0.08) [0.82;1.14] 0.704
SES	1 (0.01) [0.98;1.02] 0.979	1 (0.01) [0.98;1.02] 0.954	1.01 (0.01) [1;1.02] 0.17	1.01 (0.01) [0.99;1.03] 0.205	1 (0.01) [0.97;1.03] 0.887	1 (0.02) [0.97;1.03] 0.917
Atrial Fibrillation	-----	-----	1.08 (0.05) [0.98;1.18] 0.104	1.1 (0.06) [0.98;1.23] 0.094	-----	-----
Arthritis	0.96 (0.04) [0.89;1.05] 0.392	0.96 (0.05) [0.88;1.05] 0.403	-----	-----	-----	-----
Cancer	-----	-----	1.04 (0.05) [0.95;1.14] 0.426	1.03 (0.06) [0.92;1.16] 0.566	-----	-----
CVD	1.02 (0.05) [0.92;1.13] 0.743	1.02 (0.06) [0.91;1.14] 0.794	1.07 (0.05) [0.98;1.18] 0.146	1.08 (0.07) [0.96;1.22] 0.199	1.09 (0.11) [0.91;1.32] 0.352	1.11 (0.12) [0.9;1.37] 0.324
Liver disease	1.21 (0.13) [0.98;1.48] 0.073	1.23 (0.14) [0.98;1.53] 0.074	-----	-----	-----	-----
Dementia	1.07 (0.05) [0.97;1.17] 0.16	1.07 (0.05) [0.97;1.18] 0.2	1.02 (0.05) [0.93;1.11] 0.738	0.99 (0.06) [0.88;1.1] 0.795	1.14 (0.11) [0.95;1.37] 0.153	1.14 (0.12) [0.94;1.4] 0.18
CHD	0.86 (0.05) [0.77;0.95] 0.004	0.85 (0.05) [0.76;0.95] 0.005	1.07 (0.05) [0.97;1.18] 0.174	1.02 (0.06) [0.9;1.15] 0.785	-----	-----
Epilepsy	-----	-----	1.04 (0.1) [0.86;1.26] 0.664	1.02 (0.12) [0.82;1.28] 0.841	-----	-----
Heart Failure	1.09 (0.05) [0.99;1.2] 0.095	1.09 (0.06) [0.98;1.21] 0.11	1.07 (0.06) [0.96;1.19] 0.201	1.09 (0.07) [0.96;1.24] 0.177	1.01 (0.1) [0.83;1.22] 0.947	1.02 (0.11) [0.82;1.25] 0.885
Multiple sclerosis	-----	-----	0.76 (0.1) [0.59;0.98] 0.033	0.73 (0.11) [0.54;0.99] 0.046	-----	-----
Parkinson's	1.23 (0.11) [1.04;1.45] 0.018	1.24 (0.12) [1.03;1.49] 0.021	1.07 (0.14) [0.84;1.37] 0.582	1.11 (0.18) [0.81;1.52] 0.512	-----	-----
Renal Failure	1.04 (0.05) [0.95;1.13] 0.436	1.03 (0.05) [0.93;1.13] 0.601	1.04 (0.05) [0.94;1.15] 0.408	1.06 (0.07) [0.94;1.2] 0.366	1.11 (0.11) [0.91;1.36] 0.3	1.12 (0.13) [0.9;1.39] 0.317
Diseases of blood	1.05 (0.05) [0.97;1.14] 0.246	1.05 (0.05) [0.96;1.15] 0.308	-----	-----	-----	-----
Diabetes	-----	-----	-----	-----	1.2 (0.11) [1;1.42] 0.044	1.22 (0.12) [1.01;1.48] 0.042
Constant	26.62 (74.48) [0.11;6410.63] 0.241	8.84 (27.52) [0.02;3945.99] 0.484	295178.8 (1199605) [102.52;850000000] 0.002	1223534 (6192074) [60.23;24900000000] 0.006	1480000000000 (12700000000000) [776224.7;2.84E+20] 0	3100000000(292000000) [292677.5;3.28E+21] 0.001

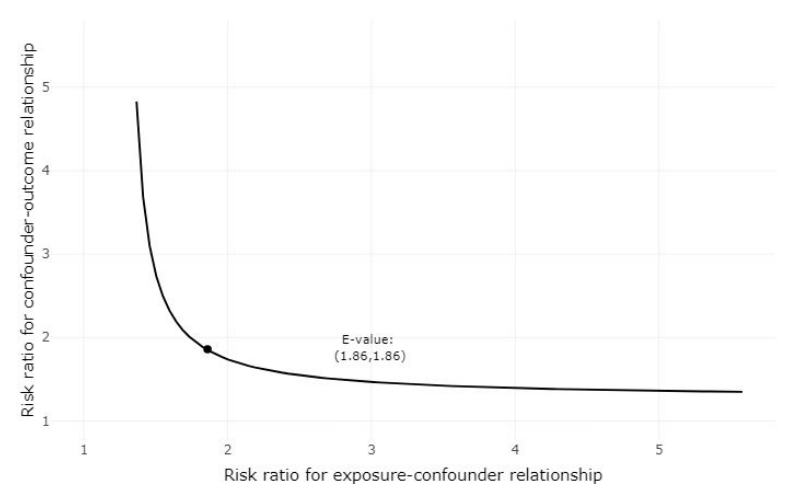
Appendix 4 Estimated E-values

Site one

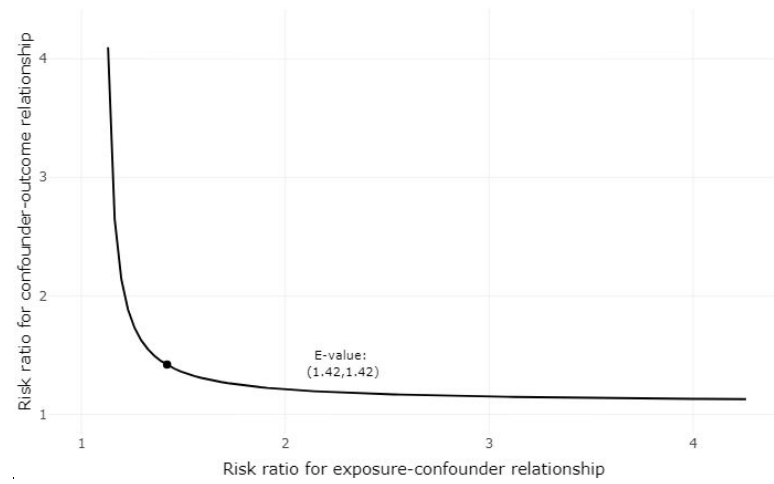
Total costs during follow-up period E-value for point estimate: 1.73 and for confidence interval: 1.49;



Total costs in 6 months after discharge E-value for point estimate: 1.86 and for confidence interval: 1.55;



Mortality rate during follow-up: E-value for point estimate: 1.42 and for confidence interval: 1.04;

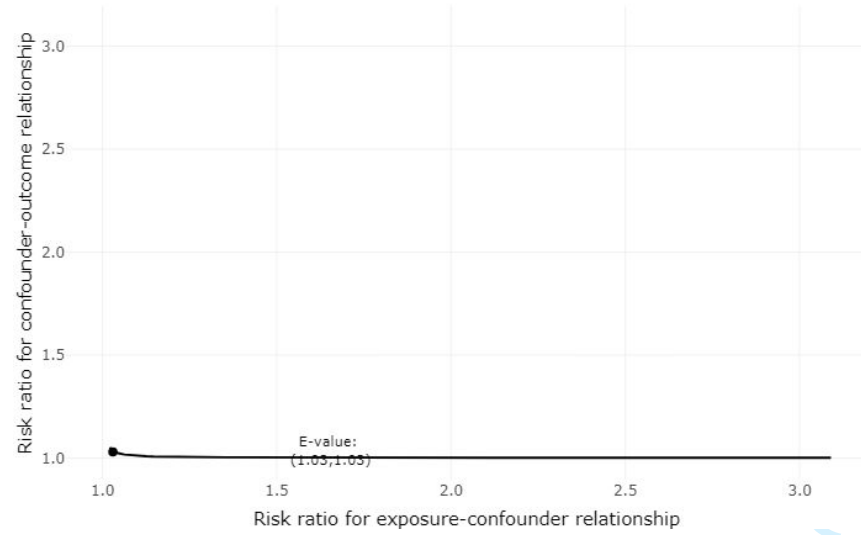


**Site two**

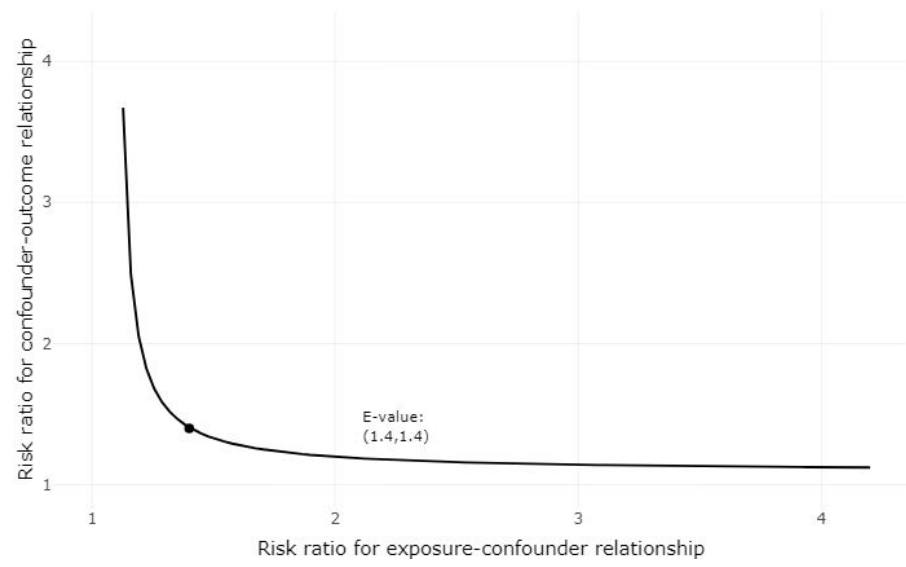
Total costs during follow-up period: E-value for point estimate: 1.03 and for confidence interval: 1

Peer review only

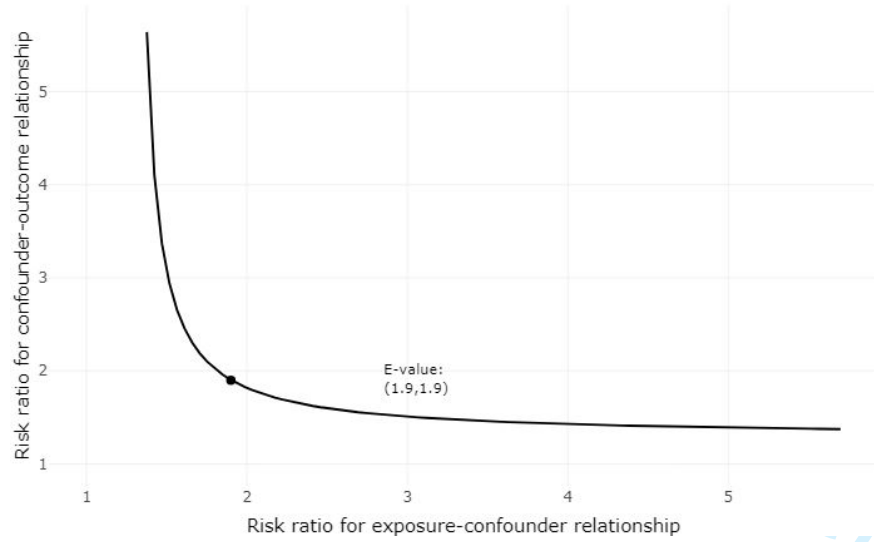
1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46



Total costs in 6 months after discharge: E-value for point estimate: 1.4 and for confidence interval: 1

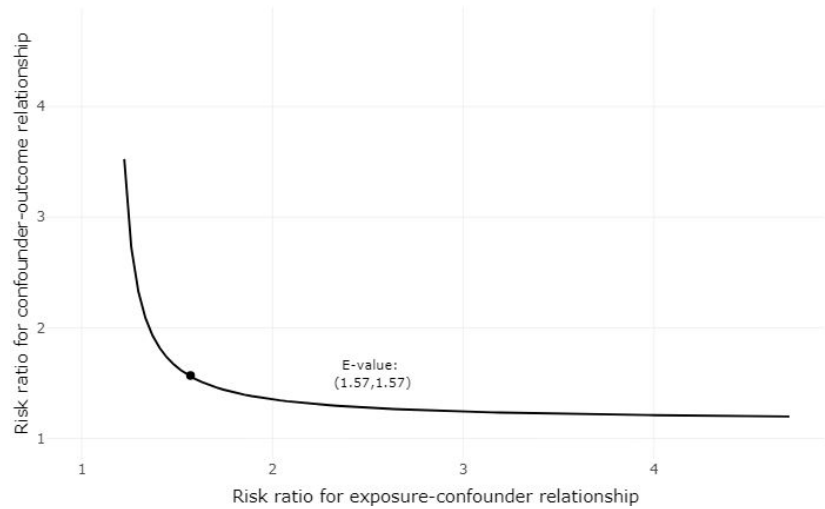


Mortality rate during follow-up: E-value for point estimate: 1.9 and for confidence interval: 1.57



**Site three**

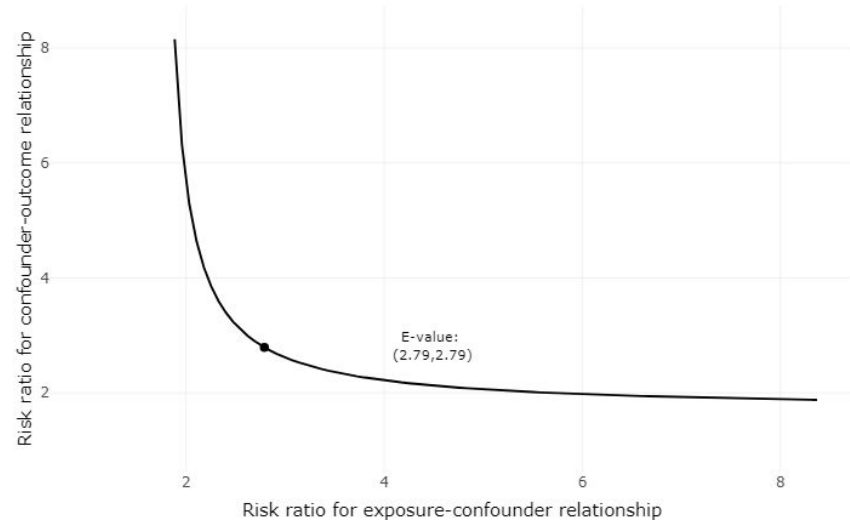
Total costs during follow-up period: E-value for point estimate: 1.57 and for confidence interval: 1



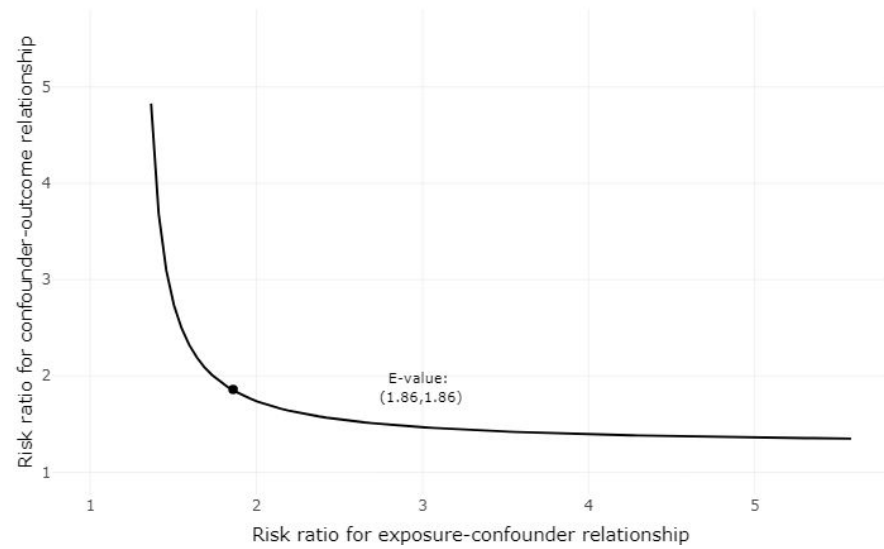
Peer review only



Total costs in 6 months after discharge: E-value for point estimate: 2.79 and for confidence interval: 2.15



Mortality rate during follow-up: E-value for point estimate: 1.86 and for confidence interval: 1.31



**The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.**

	Item No.	STROBE items	Location in manuscript where items are reported	RECORD items	Location in manuscript where items are reported
<b>Title and abstract</b>					
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	1a: page 1  1b: page 2	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included.  RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract.  RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	1.1: page 1  1.2: page 2  1.3: page 2
<b>Introduction</b>					
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	page 4		
Objectives	3	State specific objectives, including any prespecified hypotheses	page 4		
<b>Methods</b>					
Study Design	4	Present key elements of study	page 5		

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

		design early in the paper			
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	page 5-6		
Participants	6	(a) <i>Cohort study</i> - Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> - Give the eligibility criteria, and the sources and methods of selection of participants	6a: NA	RECORD 6.1: The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided.  RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided.	6.1: page 5-6  6.2 NA
		(b) <i>Cohort study</i> - For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> - For matched studies, give matching criteria and the number of controls per case	6b: page 6-8	RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	6.3 NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect	page 7-8	RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and	page 5, 7-8

		modifiers. Give diagnostic criteria, if applicable.		effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	page 6		
Bias	9	Describe any efforts to address potential sources of bias	page 6-8		
Study size	10	Explain how the study size was arrived at	page 6-8		
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	page 7-8		
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> - If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> - If applicable, explain how	12a: page 7-8  12b: page 8  12c: page 8  12d: 6-8		

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

		<p>matching of cases and controls was addressed</p> <p><i>Cross-sectional study</i> - If applicable, describe analytical methods taking account of sampling strategy</p> <p>(e) Describe any sensitivity analyses</p>	12e: page 8		
Data access and cleaning methods		..		<p>RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population.</p> <p>RECORD 12.2: Authors should provide information on the data cleaning methods used in the study.</p>	<p>12.1: page 5</p> <p>12.2: page 6</p>
Linkage		..		RECORD 12.3: State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	page 6
<b>Results</b>					
Participants	13	(a) Report the numbers of individuals at each stage of the study ( <i>e.g.</i> , numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed)	13a: page 9-10	RECORD 13.1: Describe in detail the selection of the persons included in the study ( <i>i.e.</i> , study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by	page 6, 8, 10

		(b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram	13b: page 9-10 13c: page 10	means of the study flow diagram.	
Descriptive data	14	(a) Give characteristics of study participants ( <i>e.g.</i> , demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) <i>Cohort study</i> - summarise follow-up time ( <i>e.g.</i> , average and total amount)	14a: page 9,12 14b: NA 14c: page 6,13		
Outcome data	15	<i>Cohort study</i> - Report numbers of outcome events or summary measures over time <i>Case-control study</i> - Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> - Report numbers of outcome events or summary measures	page 13		
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision ( <i>e.g.</i> , 95% confidence interval). Make clear which confounders were adjusted for and why they were included	16a: page 13, 15		

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

		(b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	16b: NA  16c: NA		
Other analyses	17	Report other analyses done— e.g., analyses of subgroups and interactions, and sensitivity analyses	page 15		
<b>Discussion</b>					
Key results	18	Summarise key results with reference to study objectives	page 15		
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	page 17	RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	page 17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	page 18-19		
Generalisability	21	Discuss the generalisability (external validity) of the study	page 15-16		

		results			
<b>Other Information</b>					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	page 19		
Accessibility of protocol, raw data, and programming code		..		RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	page 19

\*Reference: Benchimol EI, Smeeth L, Guttman A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.

\*Checklist is protected under Creative Commons Attribution ([CC BY](https://creativecommons.org/licenses/by/4.0/)) license.