Factors associated with longer wait times, admission and reattendances in older patients attending emergency departments: an analysis of linked healthcare data

Laia Maynou [1,2,3] Andrew Street [2] Christopher Burton [4] Suzanne M Mason [4] Tony Stone [4] Graham Martin [5] James van Oppen [6] Simon Conroy [7]

ABSTRACT

Background and objective Care for older patients in the ED is an increasingly important issue with the ageing society. To better assess the quality of care in this patient group, we assessed predictors for three outcomes related to ED care: being seen and discharged within 4 hours of ED arrival; being admitted from ED to hospital and reattending the ED within 30 days. We also used these outcomes to identify better-performing EDs.

Methods The CUREd Research Database was used for a retrospective observational study of all 1 039 251 attendances by 368 754 patients aged 75+ years in 18 type 1 EDs in the Yorkshire and the Humber region of England between April 2012 and March 2017. We estimated multilevel logit models, accounting for patients' characteristics and contact with emergency services prior to ED arrival, time variables and the ED itself.

Results Patients in the oldest category (95+ years vs 75–80 years) were more likely to have a long ED wait (OR=1.13 (95% CI=1.10 to 1.15)), hospital admission (OR=1.26 (95% CI=1.23 to 1.29)) and ED reattendance (OR=1.09 (95% CI=1.06 to 1.12)). Those who had previously attended (3+ vs 0 previous attendances) were more likely to have long wait (OR=1.07 (95% CI=1.06 to 1.08)), hospital admission (OR=1.10 (95% CI=1.09 to 1.12)) and ED attendance (OR=3.13 (95% CI=3.09 to 3.17)). Those who attended out of hours (vs not out of hours) were more likely to have a long ED wait (OR=1.33 (95% CI=1.32 to 1.34)), be admitted to hospital (OR=1.19 (95% CI=1.18 to 1.21)) and have ED reattendance (OR=1.07 (95% CI=1.05 to 1.08)). Those living in less deprived decile (vs most deprived decile) were less likely to have any of these three outcomes: OR=0.93 (95% CI=0.92 to 0.95), 0.92 (95% CI=0.90 to 0.94), 0.86 (95% CI=0.84 to 0.88). These characteristics were not strongly associated with long waits for those who arrived by ambulance. Emergency call handler designation was the strongest predictor of long ED waits and hospital admission: compared with those who did not arrive by ambulance; ORs for these outcomes were 1.18 (95% CI=1.16 to 1.20) and 1.85 (95% CI=1.81 to 1.89) for those designated less urgent; 1.37 (95% CI=1.33 to 1.40) and 2.13 (95% CI=2.07 to 2.18) for urgent attendees; 1.26 (95% CI=1.23 to 1.28) and 2.40 (95% CI=2.36 to 2.45) for emergency attendees; and 1.37 (95% CI=1.28 to 1.45) and 2.42 (95% CI=2.26 to 2.59) for those with life-threatening conditions. We

---

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Policymakers in England have attempted to improve the performance of EDs mainly by setting and monitoring targets for how quickly patients are managed. Other outcomes such as admission and reattendance have not been a focus of these efforts. Moreover, while it is known that longer ED waits are related to patient and ED characteristics, studies have not accounted for use of emergency calls and ambulances prior to attendance.

WHAT THIS STUDY ADDS

⇒ Using readily available system-level data, we analysed a triple metric of ED service outcomes, namely long ED waits, hospital admission and ED reattendance among 18 EDs in Yorkshire and the Humber. We control for a rich set of variables including patient characteristics, calls to emergency services and use of ambulance services prior to ED attendance, the time and day of attendance, and the size and staffing of the ED.

⇒ For those conveyed to the ED by ambulance, we identified a strong association between call handler designation of urgency with outcomes.

⇒ We identified 2 of 18 EDs whose older patients were less likely to wait more than 4 hours, to be admitted to hospital or to reattend within 30 days.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Call handler designation of urgency could be easily used to identify those at the highest risk of these outcomes upon arrival at ED.

⇒ The triple metric could be used as a measure of quality in ED care for older adults.

identified two EDs whose patients were less likely to have a long ED, hospital admission or ED reattendance than other EDs in the region.

Conclusions Age, previous attendance and attending out of hours were all associated with an increased likelihood of exceeding 4 hours in the ED, hospital

admission and reattendance among patients over 75 years. These differences were less pronounced among those arriving by ambulance. Emergency call handler designation could be used to identify those at the highest risk of long ED waits, hospital admission and ED reattendance.

INTRODUCTION

A growing evidence base for holistic care for older patients in emergency care settings demonstrates improved outcomes from person-centred, multidisciplinary, boundary-spanning care pathways.[1–6] Despite this, policy in many countries has focused on ED waiting times, such as the 4-hour standard in England which has not been achieved for some years,[7] overlookin g outcomes such as whether patients were admitted to hospital and reattended the ED. Appraisal of urgent care provision should also take account of the wider determinant of outcomes, such as patient, pathway and provider characteristics. The ED, although important, is but one part of a wider urgent care pathway that includes services that patients used prior to attending the ED, such as their emergency telephone calls and use of ambulance services. To determine the impact a specific ED can have on outcomes requires having an available large set of variables in a single database to allow us to control for patient sociodemographic and clinical characteristics, times and days of attendance, previous use of urgent care services, location, size and staffing of hospitals.

The aims of this paper were to identify patient and urgent care pathway characteristics that predict whether patients aged 75+ years were seen and discharged within 4 hours of ED arrival, were admitted from ED to hospital and reattended the ED within 30 days; and to identify better-performing EDs with respect to these outcomes.

METHODS

In this retrospective observational study, we analysed linked routine healthcare data for older patients (75+ years) who attended type 1 EDs between April 2012 and March 2017 in the Yorkshire and the Humber (Y&H) region of the UK (total population 5.5 million). Emergency care in the region over the period was provided by one ambulance service (Yorkshire Ambulance Service) with a single emergency phone number (999), an NHS telephone triage service (NHS111) and 18 type 1 EDs (24-hour consultant-led services with resuscitation facilities) across 13 acute hospital trusts. We extracted data from the CUREd Research Database (https://www.sheffield.ac.uk/scharr/research/centres/cure/projects) which collates routine NHS data from NHS111, the Yorkshire Ambulance Service Computer Aided Dispatch Data and the ED Patient Administration Systems. The database makes it possible to track each attendance from the person's initial emergency contact, through transit to the ED, to transfer from the ED.[8]

The dataset contains data on 368 754 patients aged 75+ years who attended any of the 18 type 1 EDs in the Y&H region on one or more occasions between April 2012 and March 2017. Many patients attended the ED on multiple occasions, generating 1 039 251 separate attendances, with 1% of patients attending more than 12 times over the full period. When there were multiple attendances on the same day, we analysed only the last attendance of the day. This meant 8988 out of 1 039 251 (0.86%) attendances were excluded from analyses.

Taking ED attendances as the unit of analysis, we analysed three patient outcomes: whether they were seen and discharged from the ED within 4 hours of arrival; whether they were admitted from ED to hospital; and whether they reattended the ED within 30 days of discharge either from the ED or hospital. Each outcome was analysed using a multilevel logit model, with the effect of each explanatory variable expressed in ORs.

The analyses controlled for the patients' age, sex, socioeconomic status using deciles of the Index of Multiple Deprivation (IMD),[9] number of emergency admissions in the past year, whether patients were care home residents, and for the estimated travel time by road between the patient's residence and the hospital.[10]

We included variables capturing the patient's emergency and urgent care journey prior to ED attendance, namely: the number and length of the individual's emergency (NHS111 and 999) calls; and, for those conveyed to the ED by ambulance, the urgency with which calls were accorded priority by call handlers using algorithms; time of the ambulance on scene (arrival to departure); and time taken between calling the ambulance and arrival at the ED. Those who did not make an emergency telephone call or use ambulance services were included in the analyses, but assigned values of zero for these variables act as reference categories in the main analyses.

We accounted for out-of-hours ED attendances occurring on weekends, public holidays and weekdays from 18:30 to 08:00. We controlled for daily, seasonal and annual trends by including day, month and year variables (estimates for these variables are suppressed in the tables and figures in the main paper but reported in the online supplemental material 1appendix Table A1 and Figure A1). ED size was measured using the number of attendances (in 1000s) during the year that the patient attended, and differences in staffing ratios across EDs were captured by the number of attendances divided by the number of senior doctors (accredited emergency physicians). The analysis of reattendance was conditioned on the patient surviving the ED or hospital admission.

A random effect was included for each ED site and for each patient, recognising that they might have multiple attendances, perhaps to different EDs. The random effect for each ED site is interpreted as a measure of relative performance, capturing the influence of the ED on each outcome after controlling for all the other explanatory factors.[11]

The main analyses were conducted for the full set of observations. As a robustness check, we also controlled for the percentage of available overnight hospital beds that are occupied using quarterly data. This variable was not part of the main analyses because, when included, the model estimating the probability of hospital admission failed to converge unless the year dummies were omitted. Results are reported in the online supplemental material 1 appendix (Table A2 and Figure A2).

We also conducted subgroup analyses for those who arrived at the ED by ambulance and for those who came by other means. In our analysis of whether patients waited more than 4 hours in the ED, we performed a separate subgroup analysis just for those who were not subsequently admitted to hospital.

Statistical analysis was conducted using Stata V.15 (College Station, Texas, USA).

Patient and public involvement

Patients, carers and public representatives from the Leicester, Leicestershire, and Rutland Older People's Patient and Public Involvement forum were involved in this study from its inception. Members of the forum were part of the project management team and involved in reviewing the emerging findings.
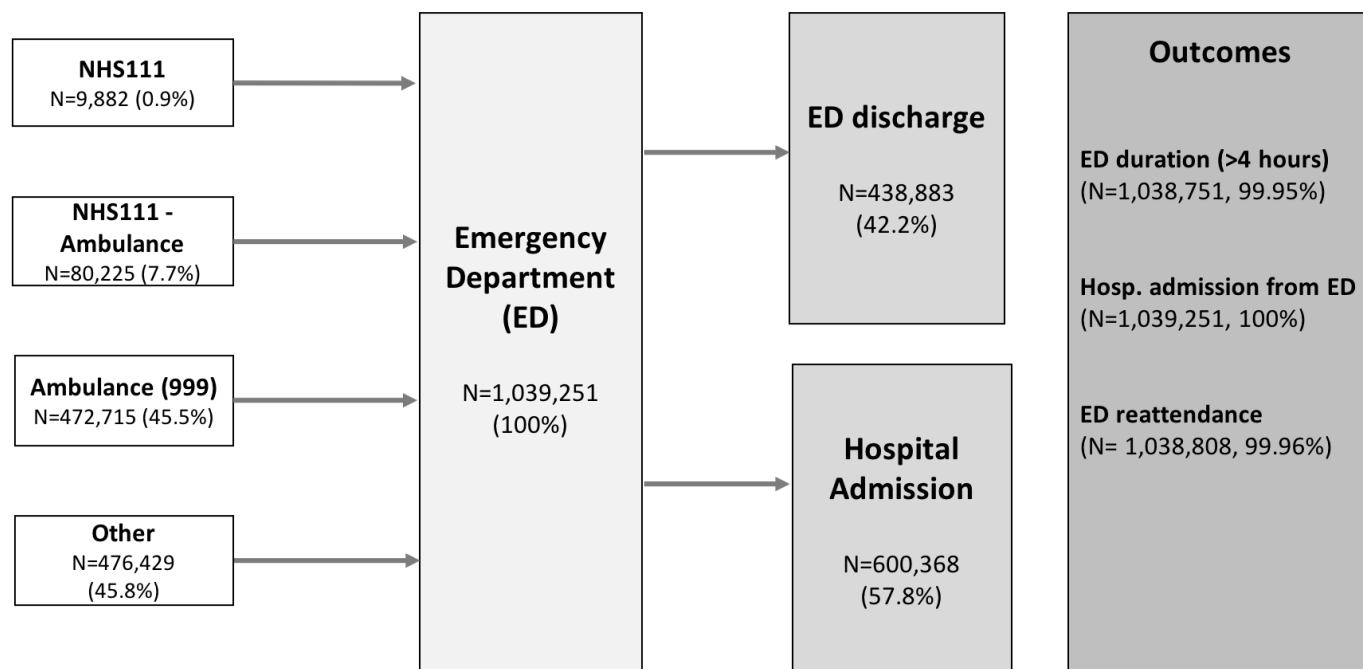
Figure 1 Emergency care pathways, 2012–2017 (type 1–18 sites). N for outcomes indicates those without missing data. Source: CUREd dataset.

RESULTS

Characteristics of study subjects

The dataset comprised a total of 1 039 251 ED attendances made by 368 754 patients aged 75+ years between April 2012 and March 2017. Figure 1 summarises the possible routes to the ED and table 1 reports summary statistics across all observations with non-missing values for each of the outcome and explanatory variables. Observations with missing data for any variable were dropped, resulting in samples of 990 172 (95.28%), 990 645 (95.32%) and 990 229 (95.28%) for the analyses of long waits, hospital admission and ED reattendance, respectively.

Of the total attendances, 90 107 (8.7%) first phoned NHS111, 6.4% making more than one call that same day and the average call lasting 15 min (SD 14), and were either advised to go directly to the ED (9882, 1.0%) or were taken by ambulance (80 225, 7.7%). A further 472 715 (45.5%) made a 999 call to the ambulance service and were transferred to the ED by ambulance. A total of 4.8% of these called 999 more than once that same day. Of all the 552 940 conveyances by ambulance, 47.9% were designated less urgent (category 4) by the call handlers, 17.4% urgent (category 3), 33.8% emergency (category 2) and 0.9% life-threatening (category 1).[12] The average time between the call for an ambulance and arrival at the ED was 80 min (SD 40), with the average time on scene being 40 min (SD 19).

The remaining 476 429 (45.8%) attendances were self-presentations and involved no prior phone contact with NHS111 or 999 and no ambulance journey.

The mean age of those attending was 83.6 years (SD 5.9), 41% were male, 17.9% lived in areas in the most deprived decile (IMD1) with 7% in the least deprived decile (IMD10). A total of 45.4% had not attended an ED in the preceding 12 months but 17.7% had attended three times or more; 17.1% of attendances were by care home residents and the average travel time was 13 min (SD 9) from the patient's place of residence to the ED. Fifty-four per cent of ED attendances were out of hours; there was a little difference across days of the week when patients attended, but higher proportions attended in December, January and February than other months.

A total of 293 102 (28.2%) attendances lasted more than 4 hours. A total of 4722 (0.5%) attendees died in the ED and 434 161 (41.8%) were cared for within and then discharged from the ED, while the remaining 600 368 (57.8%) were admitted to hospital for further treatment, of whom 48 017 (8%) died. A total of 212 050 (20.4%) reattended within 30 days of discharge.

Factors influencing ED outcomes

Figure 2 and table 2 present the results from the analyses of the three ED outcomes. Compared with those aged 75–79 years, patients aged 95+ years were more likely to stay more than 4 hours in the ED (OR=1.125, 95% CI=1.098 to 1.153), to be admitted to hospital (OR=1.257, 95% CI=1.226 to 1.288) and to reattend the ED within 30 days (OR=1.089, 95% CI=1.059 to 1.119). Men were more likely to be admitted to hospital (OR=1.099, 95% CI=1.089 to 1.109) and had a higher likelihood of ED reattendance (OR=1.116, 95% CI=1.005 to 1.128). Compared with those living in areas in the most deprived decile, those from the least deprived decile (IMD10) were less likely to spend more than 4 hours in the ED (OR=0.934, 95% CI=0.915 to 0.954), to be admitted to hospital (OR=0.917, 95% CI=0.897 to 0.936) or to reattend (OR=0.863, 95% CI=0.842 to 0.884).

Care home residents were more likely to spend more than 4 hours in the ED (OR=1.077, 95% CI=1.064 to 1.090) and less likely to be admitted to hospital (OR=0.856, 95% CI=0.846 to 0.867). Patients living closer to hospital were more likely to be admitted to hospital (OR=1.005, 95% CI=1.005 to 1.006) and were less likely to reattend (OR=0.993, 95% CI=0.992 to 0.994). Previous attendances were significantly associated with all outcomes, particularly for frequent attendees. Compared with those who had not previously attended the ED in the past year, those who had attended three or more times were more likely to spend more than 4 hours in the ED (OR=1.069, 95% CI=1.056 to 1.083), to be admitted to hospital (OR=1.104, 95% CI=1.090 to 1.118) and to reattend the ED within 30 days (OR=3.126, 95% CI=3.085 to 3.169).

Table 1 Descriptive statistics: outcomes and covariates (2012–2017)

Variables	N	n	%
ED outcomes			
ED duration (>4 hours)	1 038 751	293 102	28.22
Hospital admission from ED	1 039 251	600 368	57.77
ED reattendance within 30 days	1 038 808	212 050	20.41
Patient characteristics			
Age (median, IQR)	1 039 251	83	9
Age 75–80	1 039 251	302 234	29.08
Age 80–85	1 039 251	305 512	29.40
Age 85–90	1 039 251	250 855	24.14
Age 90–95	1 039 251	138 961	13.37
Age 95+	1 039 251	41 689	4.01
Sex (=1 male)	1 039 217	426 084	41.00
IMD1—most deprived	1 034 589	184 685	17.85
IMD2	1 034 589	103 025	9.96
IMD3	1 034 589	110 259	10.66
IMD4	1 034 589	87 630	8.47
IMD5	1 034 589	91 991	8.89
IMD6	1 034 589	103 182	9.97
IMD7	1 034 589	103 367	9.99
IMD8	1 034 589	89 697	8.67
IMD9	1 034 589	89 424	8.64
IMD10—least deprived	1 034 589	71 329	6.89
Number of previous ED attendances (1-year window) (median, IQR)	995 300	1	2
Number of previous admissions (1-year window)=0	995 300	451 990	45.41
Number of previous admissions (1-year window)=1	995 300	239 172	24.03
Number of previous admissions (1-year window)=2	995 300	127 665	12.83
Number of previous admissions (1-year window)=3+	995 300	176 473	17.73
Care home (=1 yes)	1 035 437	176 613	17.06
Road travel distance (min) (LSOA to hospital) (median, IQR)	1 034 814	10	10
Death in ED or hospital	1 039 251	52 705	5.07
Pathway variables			
Length NHS111 call (min)* (median, IQR)	90 107	10.22	8.90
Calls to NHS111 per day (>1)*	90 107	5774	6.41
Ambulance calls per day (>1)*	552 940	24 595	4.45
CH designation—less urgent	552 940	264 694	47.87
CH designation—urgent	552 940	96 199	17.40
CH designation—emergency	552 940	187 033	33.83
CH designation—life-threatening	552 940	5014	0.91
Time ambulance on scene (min)* (median, IQR)	538 087	36.1	21.65
Time from ambulance call to ED arrival (min)*† (median, IQR)	552 940	71.15	38.3
Site variables			
Site size in 1000 (financial year) (median, IQR)	1 039 251	11.92	6.92
Number of attendances per consultant (financial year) (median, IQR)	1 039 251	1388.50	967.03
Occupancy rate per trust (quarterly) (median, IQR)	1 039 251	84.45	7.29
Time variables			
Out of hours in ED (=1 yes)	1 039 251	562 545	54.13
Monday	1 039 251	156 211	15.03

Continued

Table 1 Continued

Variables	N	n	%
Tuesday	1 039 251	146 475	14.09
Wednesday	1 039 251	145 676	14.02
Thursday	1 039 251	145 886	14.04
Friday	1 039 251	148 965	14.33
Saturday	1 039 251	149 051	14.34
Sunday	1 039 251	146 987	14.14
Bank holiday (=1 yes)	1 039 251	29 706	2.86
January	1 039 251	91 581	8.81
February	1 039 251	81 889	7.88
March	1 039 251	89 752	8.64
April	1 039 251	84 017	8.08
May	1 039 251	87 292	8.40
June	1 039 251	83 788	8.06
July	1 039 251	85 871	8.26
August	1 039 251	85 107	8.19
September	1 039 251	82 874	7.97
October	1 039 251	86 338	8.31
November	1 039 251	84 768	8.16
December	1 039 251	95 974	9.23

*In the regressions, we assign 0 min to the rest of the observations.
†Ambulance on scene has missing values in the departure time.
%, percentage of observations with characteristic; CH, call handler; IMD, Index of Multiple Deprivation; LSOA, Lower Super Output Area; n, observations with characteristic; N, total observations.

Patients were more likely to spend more than 4 hours in the ED or to reattend if they made more than one NHS111 or 999 call on the day of ED attendance. For those conveyed by ambulance, the call handler designation of urgency was very strongly associated with all three outcomes. Compared with those who made their own way to the ED, the probability of waiting more than 4 hours was higher for those designated as less urgent (OR=1.178, 95% CI=1.155 to 1.202), urgent (OR=1.367, 95% CI=1.334 to 1.400), emergency (OR=1.256, 95% CI=1.233 to 1.279) and with a life-threatening condition (OR=1.365, 95% CI=1.281 to 1.453). There is also a clear gradient across urgency categories in the likelihood of hospital admission, increasing from OR=1.850 (95% CI=1.813 to 1.888) for those designated less urgent to OR=2.422 (95% CI=2.261 to 2.594) for those with life-threatening conditions. This pattern is not evident, and the effects are smaller or insignificant, when considering reattendance. The longer the ambulance was on the scene and the longer the journey to the ED, the higher the likelihood that the patient stayed more than 4 hours in the ED.

Patients who attended the ED out of hours spent longer in the ED (OR=1.329, 95% CI=1.315 to 1.344), were more likely to be admitted to hospital (OR=1.194, 95% CI=1.181 to 1.207) and were more likely to reattend (OR=1.067, 95% CI=1.054 to 1.081). The larger the ED (expressed as the number of attendances), the higher the likelihood of waiting more than 4 hours and of reattendance, but the lower the likelihood of hospital admission. The effect sizes associated with number of attendances per senior doctor were very close to OR=1 for all three outcomes.

Analysis of ED performance
The regression analyses allowed an assessment of the specific impact of the ED on patient outcomes, over and above the influence of patient and pathway characteristics, and their size and
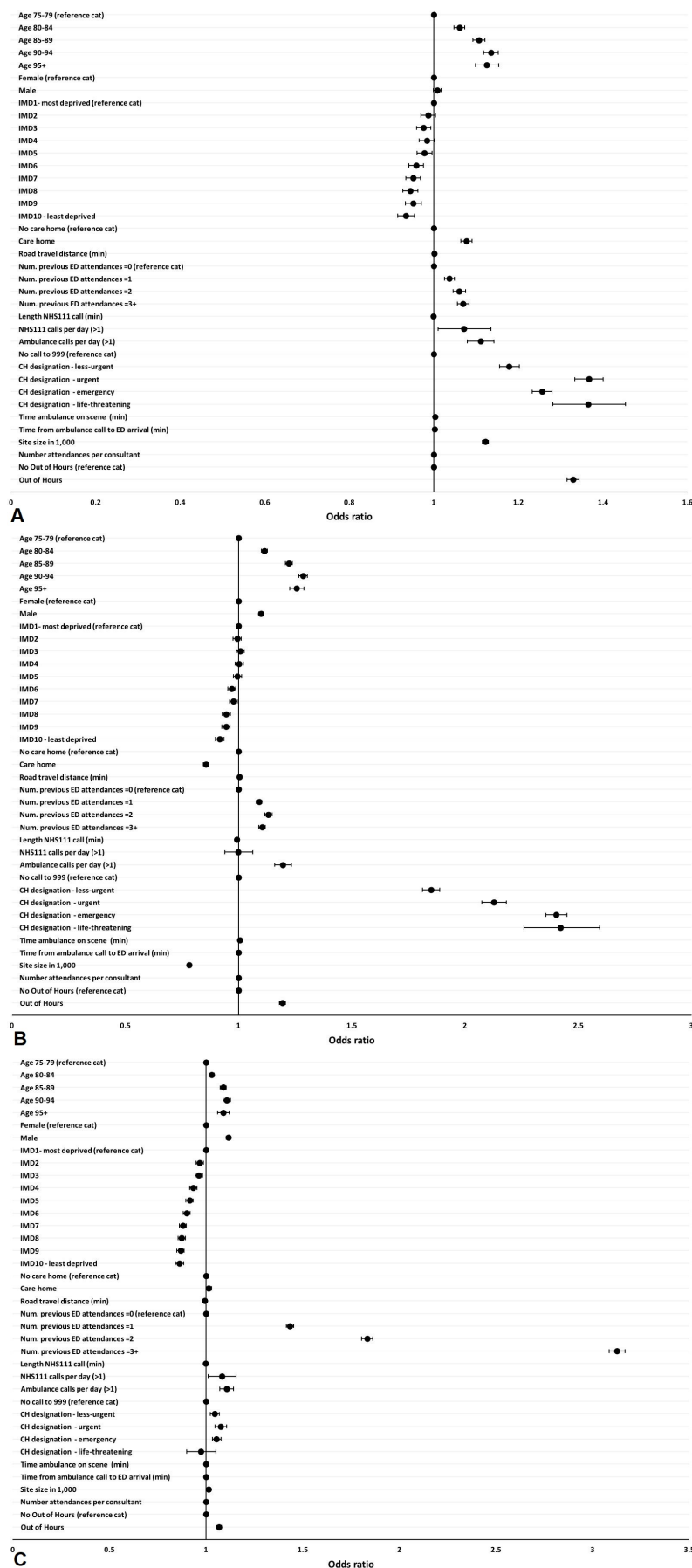
Figure 2 ED outcome estimates (2012–2017). (A) ED duration (>4 hours); (B) hospital admission from ED; (C) ED reattendance within 30 days. CH, call handler; IMD, Index of Multiple Deprivation.

Table 2   Multilevel model—ED outcome results: ED duration, hospital admission from ED and ED reattendance within 30 days (2012–2017)

Dep var	(1) ED duration (>4 hours) Logit—OR	(2) Hospital admission from ED Logit—OR	(3) 30-day reattendance Logit—OR
Age 75–80 (reference cat)	1	1	1
Age 80–85	1.061*** (1.048 to 1.073)	1.115*** (1.102 to 1.128)	1.028*** (1.015 to 1.042)
Age 85–90	1.107*** (1.093 to 1.121)	1.222*** (1.207 to 1.237)	1.088*** (1.073 to 1.104)
Age 90–95	1.135*** (1.118 to 1.153)	1.285*** (1.266 to 1.305)	1.107*** (1.089 to 1.126)
Age 95+	1.125*** (1.098 to 1.153)	1.257*** (1.226 to 1.288)	1.089*** (1.059 to 1.119)
Female (reference cat)	1	1	1
Male	1.008* (0.999 to 1.017)	1.099*** (1.089 to 1.109)	1.116***(1.105 to 1.128)
IMD1—most deprived (reference cat)	1	1	1
IMD2	0.986 (0.969 to 1.004)	0.994 (0.977 to 1.012)	0.967*** (0.949 to 0.986)
IMD3	0.976*** (0.959 to 0.993)	1.007 (0.990 to 1.025)	0.963*** (0.945 to 0.982)
IMD4	0.984* (0.965 to 1.002)	1.003 (0.984 to 1.022)	0.934*** (0.914 to 0.954)
IMD5	0.978** (0.960 to 0.996)	0.995 (0.977 to 1.014)	0.915*** (0.896 to 0.934)
IMD6	0.958*** (0.941 to 0.975)	0.970*** (0.952 to 0.987)	0.900*** (0.882 to 0.919)
IMD7	0.951*** (0.934 to 0.969)	0.978** (0.960 to 0.995)	0.880*** (0.862 to 0.898)
IMD8	0.944*** (0.926 to 0.962)	0.946*** (0.929 to 0.964)	0.874*** (0.856 to 0.893)
IMD9	0.951*** (0.933 to 0.970)	0.945*** (0.927 to 0.963)	0.868*** (0.849 to 0.887)
IMD10—least deprived	0.934*** (0.915 to 0.954)	0.917*** (0.897 to 0.936)	0.863*** (0.842 to 0.884)
No care home (reference cat)	1	1	1
Care home	1.077*** (1.064 to 1.090)	0.856*** (0.846 to 0.867)	1.014** (1.001 to 1.028)
Road travel distance (min)	1.001*** (1.001 to 1.002)	1.005*** (1.005 to 1.006)	0.993*** (0.992 to 0.994)
Number of previous ED attendances=0 (reference cat)	1	1	1
Number of previous ED attendances=1	1.037*** (1.025 to 1.049)	1.091*** (1.079 to 1.104)	1.434*** (1.415 to 1.453)
Number of previous ED attendances=2	1.060*** (1.045 to 1.076)	1.132*** (1.116 to 1.148)	1.834*** (1.806 to 1.863)
Number of previous ED attendances=3+	1.069*** (1.056 to 1.083)	1.104*** (1.090 to 1.118)	3.126*** (3.085 to 3.169)
Length NHS111 call (min)	0.999*** (0.998 to 0.999)	0.992*** (0.992 to 0.993)	0.999*** (0.998 to 0.999)
NHS111 calls per day (≤1) (reference cat)	1	1	1
NHS111 calls per day (>1)	1.071** (1.010 to 1.135)	0.999 (0.939 to 1.064)	1.081** (1.012 to 1.155)
Ambulance calls per day (≤1) (reference cat)	1	1	1
Ambulance calls per day (>1)	1.110*** (1.079 to 1.142)	1.196*** (1.160 to 1.234)	1.107*** (1.071 to 1.143)
No call to 999 (reference cat)	1	1	1
CH designation—less urgent	1.178*** (1.155 to 1.202)	1.850*** (1.813 to 1.888)	1.045*** (1.022 to 1.069)
CH designation—urgent	1.367*** (1.334 to 1.400)	2.128*** (2.074 to 2.183)	1.076*** (1.046 to 1.107)
CH designation—emergency	1.256*** (1.233 to 1.279)	2.403*** (2.357 to 2.449)	1.054*** (1.033 to 1.077)
CH designation—life-threatening	1.365*** (1.281 to 1.453)	2.422*** (2.261 to 2.594)	0.972 (0.899 to 1.052)
Time ambulance on scene (min)	1.003*** (1.002 to 1.003)	1.006*** (1.005 to 1.006)	1.001** (1.0001 to 1.001)
Time from ambulance call to ED arrival (min)	1.002*** (1.001 to 1.002)	0.999*** (0.999 to 0.999)	1.0004*** (1.0002 to 1.001)
No out of hours (reference cat)	1		
Out of hours (=1 yes)	1.329*** (1.315 to 1.344)	1.194*** (1.181 to 1.208)	1.067*** (1.054 to 1.081)
Site size in 1000	1.122*** (1.115 to 1.129)	0.781*** (0.777 to 0.786)	1.014*** (1.008 to 1.020)
Number of attendances per consultant	0.999*** (0.999 to 0.999)	1.0001*** (1.0001 to 1.0001)	1.000* (1.000 to 1.00004)
Var(j)	0.821*** (0.281 to 1.362)	2.260*** (0.784 to 3.736)	0.009*** (0.003 to 0.014)
N	990 172	990 645	990 229
Sites	18	18	18

Significance levels: ***p<0.01, **p<0.05, *p<0.1. ORs reported and 95% CIs in parentheses. Variation in the random effects across sites is captured by Var(j) reported as mean of the variance with the 95% CIs in parentheses. Model 3 (30-day reattendance) includes death as a covariate.

CH, call handler; IMD, Index of Multiple Deprivation; N, total observations.

staffing ratios. Var(j) in table 2 indicates there is significant variation among the 18 type 1 EDs in the outcomes experienced by their patients. Figure 3 plots the ED random effects and 95% CIs, indicating each ED's relative performance. Two EDs, indicated as solid lines, stood out as having significantly better performance than the average ED in Y&H with respect to all three outcomes. Patients in these two EDs were less likely to wait more than 4 hours, to be admitted to hospital or to reattend than those attending EDs elsewhere. This conclusion was robust to controlling for the bed occupancy rate in the host hospital trust (Table A2 and Figure A2 of the online supplemental material 1).

Subgroup analyses

Table A3 in the appendix reports the average outcomes for the subgroups while Figure A3 and Table A4 show the regression results for all three outcomes, according to whether patients attended the ED either by ambulance or by other means. There are clear differences between these two groups in what factors
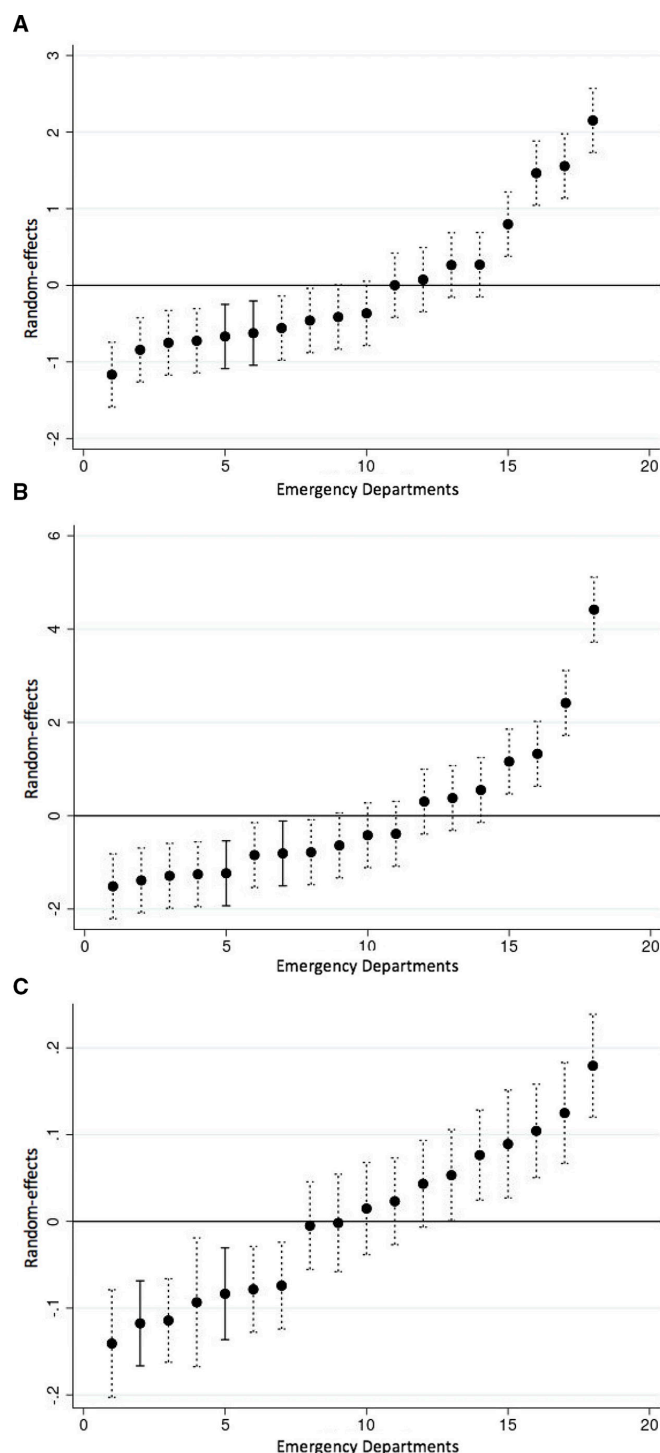
Figure 3 ED outcome random effects (18 sites) (2012–2017). (A) ED duration (>4 hours); (B) hospital admission from ED; (C) ED reattendance within 30 days.

are associated with their outcomes. For those who arrived by ambulance, few of the personal characteristics were particularly influential at explaining the likelihood of waiting more than 4 hours, other than out-of-hours attendance (OR=1.223, 95% CI=1.206 to 1.241). Out-of-hours attendance was also the most influential factor (OR=1.513, 95% CI=1.486 to 1.540) in explaining the probability of waiting more than 4 hours for those who did not arrive at the ED by ambulance, but there was also

an age gradient, as older patients faced longer ED waits, as did those from care homes (OR=1.168, 95% CI=1.143 to 1.193).

For those arriving by ambulance, the most important factors associated with admission to hospital were the call handler designation of urgency: those considered to have urgent (OR=1.347, 95% CI=1.322 to 1.373), emergency (OR=1.379, 95% CI=1.360 to 1.399) or life-threatening conditions (OR 1.640, 95% CI=1.537 to 1.751) were more likely to be admitted than those designated less urgent. Older patients were also more likely to be admitted. Age was also an important predictor of admission for those who did not arrive by ambulance, and the likelihood of admission increases the more times they had attended the ED previously and if they attended out of hours (OR=1.48, 95% CI=1.457 to 1.503).

The factors associated with 30-day reattendance were little different for those who did and did not arrive at the ED by ambulance, previous attendances being the dominant factor.

The subgroup analysis of whether patients waited more than 4 hours in the ED for those who were and were not subsequently admitted to hospital is shown in Figure A4 and Table A5. Three sets of variables stand out as having a differential effect between these two groups. First, older age had a stronger association with how long patients waited among those who were not admitted compared with those admitted. Second, call handler designation was strongly associated with spending more than 4 hours in the ED for those who were not admitted. Third, out-of-hours attendance had a lesser association with long ED duration for those who were subsequently admitted than for those who were not (OR=1.170, 95% CI=1.154 to 1.187 and OR=1.562, 95% CI=1.532 to 1.593).

DISCUSSION
Our paper offers three key contributions to the literature examining ED performance. While there are many ways to measure ED performance,[13 14] policymakers and the majority of empirical papers focus on just a single measure, typically time spent in the ED,[15–20] it being known that ED delays are harmful.[7] We follow the few studies that have considered multiple measures[21 22] by analysing three ED outcomes, namely whether patients waited in ED for more than 4 hours, were admitted from ED to hospital and reattended the ED within 30 days of discharge.

Second, our analyses recognise that EDs do not operate in isolation. We were able to contextualise ED performance as part of the urgent care pathway, notably by accounting for calls to emergency services and use of ambulance services which emerged as important predictors of outcomes.

Third, we identified the impact that each specific ED had on performance. This involved controlling for a rich set of variables including patient characteristics, use of urgent care services prior to ED attendance, the time and day of attendance, and the size and staffing of the ED. Having accounted for the influence of these variables, we identified two EDs whose patients were significantly less likely than patients in other EDs to wait more than 4 hours, to be admitted to hospital and to reattend within 30 days. Qualitative study of one of these EDs highlighted the importance of a 'frailty mindset' in delivering high-quality, responsive services, including the development of pathways and roles specifically oriented towards the needs of frail older patients, and supporting positive risk-taking in considering options for those attending ED.[23]

Some of these factors associated with ED outcomes are already well known, notably that those of higher age, with a history of attendance, who attend out of hours and are from

more deprived areas have a greater likelihood of a longer ED wait, hospital admission and ED reattendance.[24–28] But we offer novel insights. First, our subgroup analysis revealed that personal characteristics were not strong influences on long waits for those who arrived by ambulance, suggesting they were afforded priority based primarily on their clinical urgency rather than any other characteristic. Second, we identified the importance of call handler designation for those conveyed to the ED by ambulance. This could be used to identify upon arrival at ED those at the highest risk of a long ED wait, hospital admission and ED reattendance. Call handler designations are routinely captured in electronic Patient Report Forms but often not in handwritten ones, and may not be routinely considered by professionals working in the ED. Given the characteristics of those prioritised urgent by call handlers, and the emerging evidence base for frailty-attuned interventions in the ED,[2 29] it might be that senior decision-makers (qualified specialists, senior trainees or other senior healthcare staff such as advanced nurse practitioners) delivering initial assessment could use the designation to inform early intervention discussions or involvement of professionals with frailty expertise. Third, we identified that the ED itself may be a factor in explaining the three outcomes.

Our study demonstrates that performance can be measured not only with reference to a time-based standard but using a combination of metrics: ED duration (>4 hours), hospital admission from ED and ED reattendance within 30 days. This triple metric has the advantage of taking account of ED disposition, admission and reattendance, providing a more holistic, system-oriented service measure. As healthcare systems start to operate in more integrated ways (for example, Integrated Care Systems in England[30]), relatively simple barometers of system-wide urgent care pathway performance might be attractive to policymakers and commissioners. In combination with more person-centred metrics (for example, Patient-Reported Outcome Measures which are being developed for urgent care for older patients living with frailty[31 32]), the triple metric might help drive more person-centred, system-based emergency care approaches.

The strengths of this study include the large longitudinal dataset which captured information from a region with diverse EDs. We controlled for a wide range of patient characteristics and measures of the urgent care pathway not considered in previous studies of ED performance.

Our analysis was limited to routinely available data, which prioritise service and system-level over patient-centred outcomes.[33] Even though diagnoses are likely to be important predictors of ED outcomes,[34] unfortunately the ED data in the CUREd database do not capture diagnoses codes accurately or in a consistent fashion across EDs, with 61.5% of attendances having no diagnostic information recorded at all. While frailty identification is now commonplace in EDs,[35] no measure of frailty could be constructed from our data for those attending the ED, only for those admitted to hospital.[36] The staffing data identify only senior doctors but no other staff working in the ED and only quarterly data about bed occupancy rates were available for the period covered. It may be that the outcomes seen in the two 'high-performing' sites were related to the ED 'model of care' or wider organisational characteristics, such as an improvement culture.[23]

In summary, we have presented a comprehensive analysis of urgent care use by older patients to assess factors associated with the probabilities of a long ED wait, hospital admission and ED reattendance. While confirming the previously established influence of factors such as age, history of use and out-of-hours attendance, we identified that the emergency call handler designation was the most powerful predictor. The call handler designation could be added to other risk stratification measures (early warning scores, frailty measures) to identify patients with the highest risk of long ED waits, admission or reattendance, prompting assessment by a senior clinician at the point of arrival.

ORCID iDs
Laia Maynou http://orcid.org/0000-0002-0447-2959
Andrew Street http://orcid.org/0000-0002-2540-0364
Christopher Burton http://orcid.org/0000-0003-0233-2431
Suzanne M Mason http://orcid.org/0000-0002-1701-0577
Tony Stone http://orcid.org/0000-0002-0167-3800
Graham Martin http://orcid.org/0000-0003-1979-7577
James van Oppen http://orcid.org/0000-0002-2570-7112
Simon Conroy http://orcid.org/0000-0002-4306-6064

REFERENCES

1 Mooijaart SP, Carpenter CR, Conroy SP. Geriatric emergency medicine-a model for frailty friendly healthcare. *Age Ageing* 2022;51:afab280.
2 Preston L, van Oppen JD, Conroy SP, *et al*. Improving outcomes for older people in the emergency department: a review of reviews. *Emerg Med J* 2021;38:882–8.
3 Carpenter CR, Shelton E, Fowler S, *et al*. Risk factors and screening instruments to predict adverse outcomes for undifferentiated older emergency department patients: a systematic review and meta-analysis. *Acad Emerg Med* 2015;22:1–21.
4 Galvin R, Gilleit Y, Wallace E, *et al*. Adverse outcomes in older adults attending emergency departments: a systematic review and meta-analysis of the identification of seniors at risk (ISAR) screening tool. *Age Ageing* 2017;46:179–86.
5 Bone AE, Evans CJ, Henson LA, *et al*. Patterns of emergency department attendance among older people in the last three months of life and factors associated with frequent attendance: a mortality follow-back survey. *Age Ageing* 2019;48:680–7.
6 Elliott A, Taub N, Banerjee J, *et al*. Does the clinical frailty scale at triage predict outcomes from emergency care for older people? *Ann Emerg Med* 2021;77:620–7.
7 Jones S, Moulton C, Swift S, *et al*. Association between delays to patient admission from the emergency department and all-cause 30-day mortality. *Emerg Med J* 2022;39:168–73.
8 Lewis J, Stone T, Simpson R, *et al*. Patient compliance with NHS 111 advice: analysis of adult call and ED attendance data 2013-2017. *PLoS One* 2021;16:e0251362.
9 Ministry of Housing, Communities and Local Government. The English indices of deprivation, 2015. Available: https://www.gov.uk/ government/statistics/english-indices-of-deprivation-2015 [Accessed 12 Jun 2020].
10 Bankart MJG, Baker R, Rashid A, *et al*. Characteristics of general practices associated with emergency admission rates to hospital: a cross-sectional study. *Emerg Med J* 2011;28:558–63.
11 Gutacker N, Street A. Multidimensional performance assessment of public sector organisations using dominance criteria. *Health Econ* 2018;27:e13–27.
12 Yorkshire Ambulance Service NHS Trust. What happens when you call 999? Available: https://www.yas.nhs.uk/our-services/ emergency-ambulance-service-999/what-happens-when-you-call-999/ [Accessed 19 Apr 2022].
13 Welch S, Augustine J, Camargo CA, *et al*. Emergency department performance measures and benchmarking Summit. *Acad Emerg Med* 2006;13:1074–80.
14 Sibbritt D, Isbister GK, Walker R. Emergency department performance indicators that encompass the patient journey. *Qual Manag Health Care* 2006;15:27–38.
15 Sørup CM, Jacobsen P, Forberg JL. Evaluation of emergency department performance - a systematic review on recommended performance and quality-in-care measures. *Scand J Trauma Resusc Emerg Med* 2013;21:62.
16 Horwitz LI, Green J, Bradley EH. US emergency department performance on wait time and length of visit. *Ann Emerg Med* 2010;55:133–41.
17 Gaughan J, Kasteridis P, Mason A, *et al*. Why are there long waits at English emergency departments? *Eur J Health Econ* 2020;21:209–18.
18 Günal MM, Pidd M. Understanding target-driven action in emergency department performance using simulation. *Emerg Med J* 2009;26:724–7.
19 Capuano F, Lot A-S, Sagnes-Raffy C, *et al*. Factors associated with the length of stay of patients discharged from emergency department in France. *Eur J Emerg Med* 2015;22:92–8.
20 Gruber J, Hoe TP, Stoye G. Saving lives by tying hands: the unexpected effects of constraining health care providers. *National Bureau of Economic Research* 2018;24445.
21 Sivey P, McAllister R, Vally H, *et al*. Anatomy of a demand shock: quantitative analysis of crowding in hospital emergency departments in Victoria, Australia during the 2009 influenza pandemic. *PLoS One* 2019;14:e0222851.
22 Turner AJ, Anselmi L, Lau Y-S, *et al*. The effects of unexpected changes in demand on the performance of emergency departments. *Health Econ* 2020;29:1744–63.
23 Conroy SP, Brailsford S, Burton C, *et al*. *Identifying models of care to improve outcomes for older people with urgent care needs: a mixed methods approach to develop a system dynamics model*. Health Services and Delivery Research, 2022. https://www.journalslibrary.nihr.ac.uk/hsdr/#/
24 Locker TE, Mason SM. Analysis of the distribution of time that patients spend in emergency departments. *BMJ* 2005;330:1188–9.
25 Mason S, Nicholl J, Locker T. Targets still lead care in emergency departments. *BMJ* 2010;341:c3579.
26 Mohammed MA, Deeks JJ, Girling A, *et al*. Evidence of methodological bias in hospital standardised mortality ratios: retrospective database study of English hospitals. *BMJ* 2009;338:b780.
27 Mohammed MA, Sidhu KS, Rudge G, *et al*. Weekend admission to hospital has a higher risk of death in the elective setting than in the emergency setting: a retrospective database study of national health service hospitals in England. *BMC Health Serv Res* 2012;12:87.
28 Rudge GM, Mohammed MA, Fillingham SC, *et al*. The combined influence of distance and neighbourhood deprivation on emergency department attendance in a large English population: a retrospective database study. *PLoS One* 2013;8:e67943.
29 Turner J, Coster J, Chambers D, *et al*. What evidence is there on the effectiveness of different models of delivering urgent care? A rapid review. *Health Serv Deliv Res* 2015;3:1–134.
30 NHS England and NHS Improvement. Integrating care. next steps T building strong and effective integrated care systems across England, 2020. Available: https://www.england.nhs.uk/wp-content/uploads/2021/01/integrating-care-next-steps-to-building-strong-and-effective-integrated-care-systems.pdf [Accessed 26 Apr 2022].
31 van Oppen JD, Coats TJ, Conroy SP, *et al*. What matters most in acute care: an interview study with older people living with frailty. *BMC Geriatr* 2022;22:156.
32 van Oppen JD, Alshibani A, Coats TJ, *et al*. A systematic review and recommendations for prom instruments for older people with frailty in emergency care. *J Patient Rep Outcomes* 2022;6:30.
33 Todd OM, Burton JK, Dodds RM, *et al*. New horizons in the use of routine data for ageing research. *Age Ageing* 2020;49:716–22.
34 Parkinson B, Meacock R, Checkland K, *et al*. Unseen patterns of preventable emergency care: emergency department visits for ambulatory care sensitive conditions. *J Health Serv Res Policy* 2022;27:232–41.
35 NHS Improvement. Ambulatory emergency care guide: same day acute frailty services: same day acute frailty services, 2019. Available: https://www.england.nhs.uk/wp-content/uploads/2021/02/SDEC_guide_frailty_May_2019_update.pdf [Accessed 26 Apr 2022].
36 Street A, Maynou L, Gilbert T, *et al*. The use of linked routine data to optimise calculation of the hospital frailty risk score on the basis of previous hospital admissions: a retrospective observational cohort study. *Lancet Healthy Longev* 2021;2:e154–62.

Factors associated with longer wait times, admission and reattendances in older patients attending emergency departments. An analysis of linked healthcare data

Laia Maynou[1,2,3], Andrew Street[2], Chris Burton[4], Suzanne Mason[4], Tony Stone[4], Graham Martin[5], James van Oppen[6] and Simon Conroy[7]

[1]Department of Econometrics, Statistics and Applied Economics, Universitat de Barcelona, Avinguda Diagonal, 690, 08034, Barcelona, Spain

[2]Department of Health Policy, London School of Economics and Political Science, Houghton Street, London, WC2A 2AE, UK

[3]Center for Research in Health and Economics (CRES), Universitat Pompeu Fabra, Ramon Trias Fargas 25-27 08005 Barcelona, Spain

[4]CURE group, School of Health and Related Research, University of Sheffield, S1 4DA, UK

[5]THIS Institute, University of Cambridge, Clifford Allbutt Building, Cambridge Biomedical Campus, Cambridge, CB2 0AH, UK

[6]Department of Health Sciences, University of Leicester, George Davies Centre, University Road, Leicester, LE1 7RH, UK

[7]University College London, Medical Research Council Unit for Lifelong Health and Ageing at UCL, 5th Floor, 1-19 Torrington Place, London, WC1E 7HB, UK

1

Appendix

Description of data and variables

The analyses employed the CUREd research database, which links NHS data at individual level from NHS111, the Yorkshire Ambulance Service Computer Aided Dispatch (CAD) Data, the Emergency Department Patient Administration Systems (PAS) and the Admitted Patient Care (APC) dataset. The linkage is described in Lewis et al [1]. The analytical sample comprised all those older aged 75 or older who attended a type 1 ED in the Yorkshire and Humber region between April 2012 and March 2017.

We analysed three outcomes for patients attending ED. The first outcome was whether they were seen and discharged from the ED within four hours of arrival, calculated by comparing time of arrival in the ED and departure time from the ED. The second was whether they were transferred from the ED and admitted to hospital, determined by seeing if the same patient appeared in the APC dataset within 24 hours of being transferred from the ED. A 24 hour window was applied because only dates not time is recorded in the APC, and some people are transferred overnight. The third was whether the patient re-attended the ED within 30 days of discharge either from the ED or hospital, this being ascertained by looking at the gap between dates of ED discharge and subsequent attendance in the linked data.

The analyses controlled for a set of socio-demographic and clinical characteristics including: the patients' age, categorized into 5-year age bands; sex; the socioeconomic conditions of where they lived using the deciles of Index of Multiple Deprivation (IMD) [2], with IMD=1 indicating the worst-off communities; number of ED attendances in the past year; whether the patient's postcode indicated that they were a care home resident; and the travel time by road between the patient´s residence and the hospital [3]. The analysis of re-attendance was conditioned on the patient surviving the ED or hospital admission, identified from the PAS attendance disposal and APC discharge method variables.

We included a set of variables capturing the patient's emergency and urgent care journey prior to admission. For those that made emergency calls, we accounted for the number and length in minutes of the individual´s emergency (NHS111 and 999) calls. For those conveyed to the ED ambulance, we included variables measuring: the time of the ambulance on scene (arrival to departure); the time taken between calling the ambulance and arrival at the emergency department; and the urgency with which the ambulance was dispatched, assigned by the NHS Pathways triage system based on answers from the caller to scripted questions asked by the call-handler [4].

We included variables accounting for the day of ED attendance, whether or not the ED attendance was out-of-hours (all weekend and weekday from 6.30pm to 8am) and whether this was on a public holiday [5]; and month and financial year variables capturing seasonal effects and annual trends. These variables are not reported in the tables of results or forest plots.

We use number of attendances (in 1000s) during the year that the patient attended in order account for the size of the ED. We also construct patient-to-doctor ratios, using annual data constructed from NHS workforce statistics which record the number of full time equivalent senior A&E doctors (referred to as "consultants" in England) in each hospital trust [6]. For trusts with more than one A&E site, doctors were allocated according to the share of attendances.

Table A1: Multilevel model - ED duration, Hospital admission from ED and ED reattendance within 30 days - 2012-2017. Time variables

Dep var:	(1) ED duration (>4 hours)	(2) Hospital admission from ED	(3) 30-day reattendance
	Logit - Odds ratio	Logit - Odds ratio	Logit - Odds ratio
Bank holiday	0.979	1.116***	1.027*
	(0.953-1.007)	(1.086-1.147)	(0.996-1.060)
Thursday	0.933***	0.988	0.996
	(0.917-0.950)	(0.971-1.004)	(0.977-1.015)
Friday	0.899***	0.976***	0.996
	(0.883-0.914)	(0.960-0.993)	(0.978-1.015)
Saturday	0.794***	0.846***	0.971***
	(0.780-0.809)	(0.831-0.861)	(0.951-0.991)
Sunday	0.910***	0.874***	0.965***
	(0.894-0.927)	(0.858-0.890)	(0.945-0.984)
Monday	1.272***	0.971***	0.987
	(1.251-1.293)	(0.955-0.988)	(0.968-1.005)
Tuesday	1.106***	0.985*	0.967***
	(1.088-1.125)	(0.969-1.002)	(0.948-0.985)
May	0.845***	0.928***	0.996
	(0.826-0.864)	(0.908-0.948)	(0.972-1.021)
June	0.874***	0.922***	0.978*
	(0.854-0.895)	(0.901-0.942)	(0.954-1.003)
July	0.859***	0.909***	0.970**
	(0.839-0.878)	(0.890-0.930)	(0.946-0.994)
August	0.865***	0.914***	0.992
	(0.0.845-0.885)	(0.894-0.934)	(0.967-1.016)
September	0.955***	0.940***	0.968**
	(0.933-0.977)	(0.920-0.961)	(0.944-0.993)
October	1.183***	0.970***	0.978*
	(1.157-1.209)	(0.949-0.992)	(0.954-1.002)
November	1.238***	0.988	1.002
	(1.211-1.266)	(0.967-1.011)	(0.978-1.028)
December	1.403***	0.978**	1.015
	(1.373-1.434)	(0.958-0.999)	(0.991-1.040)
January	1.444***	1.003	0.982
	(1.413-1.476)	(0.982-1.025)	(0.958-1.006)
February	1.390***	0.991	0.975*
	(1.360-1.422)	(0.969-1.014)	(0.951-1.0002)
March	1.204***	0.942***	0.857***
	(1.178-1.231)	(0.922-0.963)	(0.836-0.879)
2013-2014	0.911***	1.088***	1.006
	(0.896-0.927)	(1.071-1.105)	(0.988-1.024)
2014-2015	1.241***	1.342***	0.986
	(1.220-1.261)	(1.321-1.363)	(0.968-1.004)
2015-2016	1.320***	1.437***	0.995
	(1.297-1.344)	(1.412-1.462)	(0.977-1.014)
2016-2017	1.424***	1.588***	0.953***
	(1.393-1.455)	(1.555-1.622)	(0.931-0.975)
N	990,172	990,645	990,229
Sites	18	18	18
Time Fixed-Effects (day, month, financial year)	Yes	Yes	Yes
Random-Effects levels	Site & patient	Site & patient	Site & patient
Years	2012-2017	2012-2017	2012-2017

Notes: See note to Table 1 for abbreviations. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Odds ratios reported and 95% confidence interval (CI) in parentheses. Model 3 (30-day reattendance) includes death as a covariate. Reference categories: No bank holiday, Wednesday, April and 2012-2013.

3

Figure A1: ED outcomes estimates (2012-2017) all variables
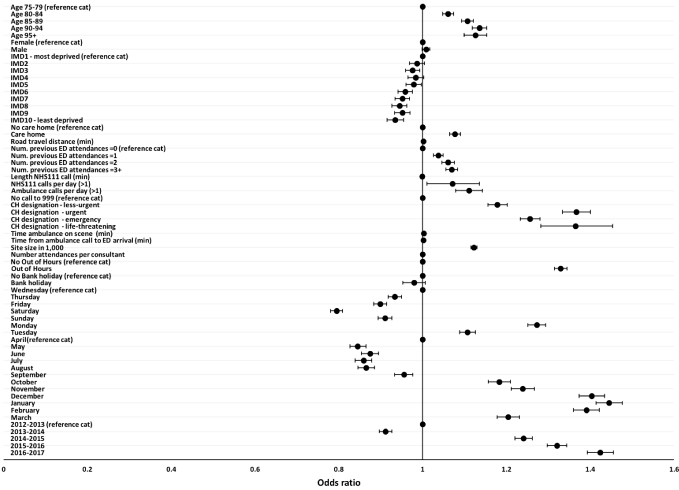
(I) - ED duration (>4 hours)
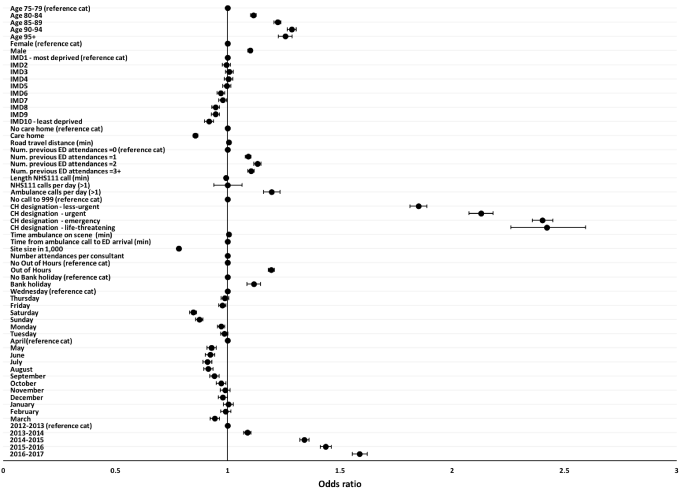
(II) - Hospital admission from ED
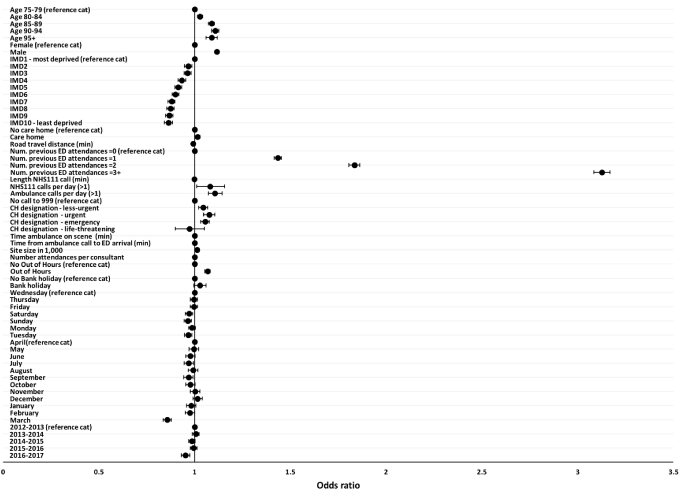
(III) - ED re-attendance within 30 days

Notes: See note to Table 1 for abbreviations.

Robustness check: accounting for bed occupancy rate

There is evidence that ED performance is related to capacity constraints, notably the availability of beds, in the host hospital [7; 8; 9]. To explore this, we ran analyses that also controlled for the percentage of overnight hospital beds that are occupied using quarterly data reported by NHS England for each hospital Trust [10]. These quarterly data are an imperfect indication of whether or not a bed might be available for any particular person requiring admission from the ED but daily data were unavailable for the period covered by our study.

When including quarterly bed occupancy rate, the model estimating the probability of hospital admission failed to converge unless the year dummies were omitted. Omitting year dummies biases the estimates of most of the other variables in the model away from OR=1, whereas omission of the bed occupancy rate has negligible impact on the other estimates. Hence, the decision was made to retain year dummies and omit bed occupancy rate in the main analysis.

Conclusions about the relative performance of EDs were also robust to omission or inclusion of the bed occupancy rate variable. The same two ED sites were identified as having patients that were significantly less likely than patients in other EDs to wait more than four hours, to be admitted to hospital and to re-attend within 30 days. Similarly, no other ED was found in which patients were significantly less (or more) likely than the national average to have longer waits, be admitted or re-attend when accounting for bed occupancy rate.

Table A2: Multilevel model - ED duration, Hospital admission from ED and ED reattendance within 30 days - 2012-2017. Robustness check (occupancy rate)

Dep var:	(1) ED duration (>4 hours)	(2) Hosp admission from ED	(3) 30-day reattedance
	Logit - Odds ratio	Logit - Odds ratio	Logit - Odds ratio
Age 80-85	1.061***	1.128***	1.028***
	(1.048-1.074)	(1.116-1.141)	(1.015-1.042)
Age 85-90	1.107***	1.255***	1.088***
	(1.093-1.121)	(1.240-1.269)	(1.073-1.104)
Age 90-95	1.135***	1.332***	1.107***
	(1.118-1.153)	(1.313-1.351)	(1.089-1.126)
Age 95+	1.126***	1.300***	1.089***
	(1.099-1.154)	(1.270-1.331)	(1.059-1.119)
Sex (=1 male)	1.008*	1.118***	1.116***
	(0.999-1.017)	(1.108-1.128)	(1.105-1.128)
IMD2	0.987	0.994	0.967***
	(0.969-1.005)	(0.977-1.011)	(0.949-0.986)
IMD3	0.974***	1.009	0.963***
	(0.957-0.991)	(0.993-1.026)	(0.945-0.982)
IMD4	0.983*	1.005	0.934***
	(0.964-1.002)	(0.987-1.023)	(0.914-0.954)
IMD5	0.978**	0.995	0.915***
	(0.959-0.996)	(0.977-1.012)	(0.896-0.934)
IMD6	0.958***	0.968***	0.900***
	(0.941-0.976)	(0.951-0.984)	(0.882-0.919)
IMD7	0.952***	0.976***	0.880***
	(0.935-0.969)	(0.959-0.993)	(0.862-0.898)
IMD8	0.945***	0.941***	0.874***
	(0.927-0.963)	(0.925-0.958)	(0.856-0.893)
IMD9	0.950***	0.937***	0.868***
	(0.932-0.969)	(0.921-0.955)	(0.849-0.887)
IMD10 - least deprived	0.934***	0.905***	0.863***
	(0.914-0.954)	(0.887-0.923)	(0.842-0.884)
Care Home (=1 yes)	1.075***	0.832***	1.014**
	(1.062-1.088)	(0.822-0.842)	(1.0001-1.028)
Road travel distance (min)	1.001***	1.006***	0.993***
	(1.001-1.002)	(1.005-1.006)	(0.992-0.994)
Num. previous ED attendances =1	1.037***	1.110***	1.434***
	(1.025-1.049)	(1.099-1.122)	(1.415-1.453)
Num. previous ED attendances =2	1.061***	1.162***	1.834***
	(1.046-1.077)	(1.146-1.177)	(1.806-1.863)
Num. previous ED attendances =3+	1.071***	1.131***	3.126***
	(1.058-1.085)	(1.117-1.145)	(3.085-3.168)
Length NHS111 call (min)	0.999***	0.993***	0.999***
	(0.998-0.999)	(0.992-0.993)	(0.998-0.999)
NHS111 calls per day (>1)	1.078**	1.002	1.081**
	(1.016-1.143)	(0.945-1.064)	(1.012-1.155)
Ambulance calls per day (>1)	1.112***	1.280***	1.107***
	(1.081-1.145)	(1.243-1.318)	(1.071-1.143)
CH designation - less-urgent	1.173***	1.828***	1.045***
	(1.150-1.197)	(1.794-1.864)	(1.022-1.069)
CH designation - urgent	1.359***	2.427***	1.076***
	(1.326-1.392)	(2.372-2.482)	(1.046-1.107)
CH designation - emergency	1.254***	2.529***	1.054***
	(1.231-1.278)	(2.484-2.576)	(1.032-1.077)
CH designation - life-threatening	1.375***	2.837***	0.972
	(1.290-1.465)	(2.656-3.030)	(0.899-1.052)
Time ambulance on scene (min)	1.003***	1.007***	1.001**
	(1.002-1.003)	(1.007-1.008)	(1.0001-1.001)
Time from ambulance call to ED arrival (min)	1.002***	1.0001	1.0004***
	(1.001-1.002)	(0.999-1.0002)	(1.0002-1.001)
Out of Hours (=1 yes)	1.330***	1.227***	1.067***
	(1.315-1.344)	(1.214-1.240)	(1.054-1.081)
Site size in 1,000	1.139***	0.865***	1.013***
	(1.132-1.146)	(0.861-0.869)	(1.007-1.019)
Number attendances per consultant	0.999***	1.00002**	1.00002*
	(0.999-0.999)	(1.000001-1.00004)	(0.999-1.00004)
Occupancy rate per trust	1.028***	1.003***	0.999*
	(1.027-1.030)	(1.002-1.004)	(0.997-1.0001)
Var(j)	0.821***	0.605***	0.008***
	(0.284-1.357)	(0.210-1.0001)	(0.003-0.014)
N	990,172	990,645	990,229
Sites	18	18	18
Time Fixed-Effects (day, month, financial year)	Yes	Yes+	Yes
Random-Effects levels	Site & patient	Site & patient	Site & patient
Years	2012-2017	2012-2017	2012-2017

Notes: See note to Table 1 for abbreviations. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Odds ratios reported and 95% CI in parentheses. Var(j) reports the estimate and the 95% CI in parentheses. Model 3 (30-day reattendance) includes death as a covariate. Reference categories: Age 75-79, Female, IMD1 - most deprived, Previous ED attendances=0, No care home, NHS111 calls per <1, Ambulance (999) per day <1, No call to 999, No Out of Hours.+financial year dummies not included.

6

Figure A2: ED outcomes residuals (18 sites) - (2012-2017) - Robustness check (with occupancy rate).

(I) - ED duration (>4 hours)

(II) - Hospital admission from ED

(III) - ED reattendance within 30 days

7
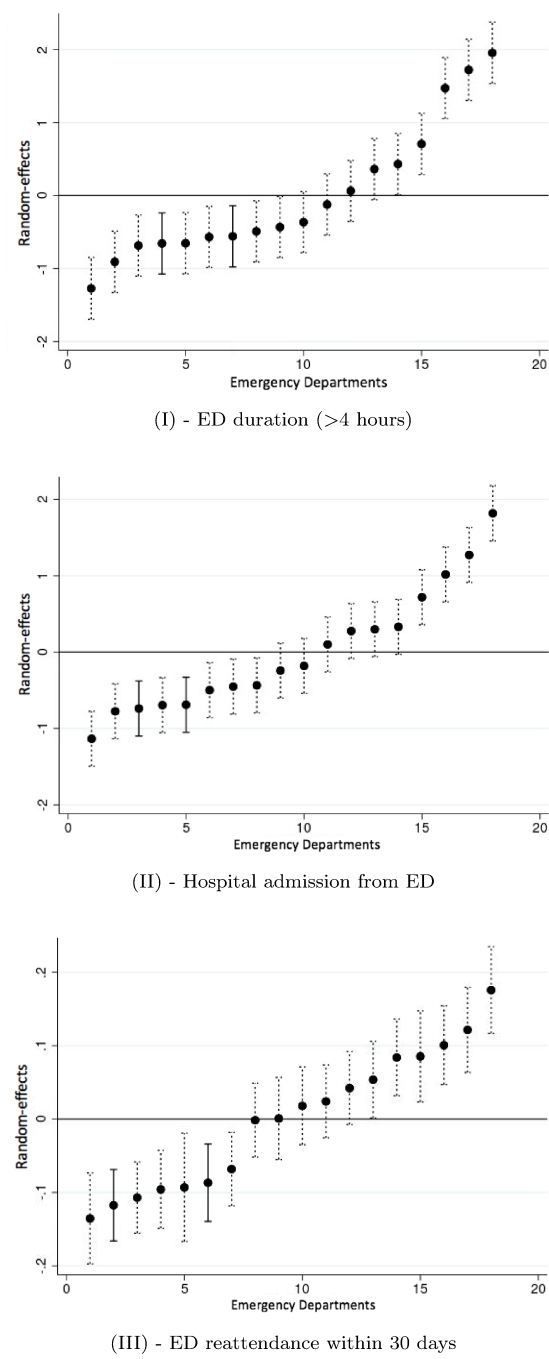
Sub-group analyses

Table A3: Outcomes by sub-groups

	Ambulance N=552,940	Non-Ambulance N=486,311	Admitted to hosp. N=600,368	Non-admitted to hosp. N=438,883
ED duration (>4 hours)	33.43 (47.18)	22.29 (41.62)	34.71 (47.61)	19.32 (39.48)
Hospital admission from ED	70.71 (45.51)	43.06 (49.52)		
ED reattendance within 30 days	21.66 (41.19)	19.00 (39.23)		

Notes: See note to Table 1 for abbreviations. % (SD)

8

Table A4: Multilevel model - ED outcomes' results sub-group analysis (Ambulance vs Non-ambulance): ED duration, Hospital admission from ED and ED reattendance within 30 days - 2012-2017.

| Dep var:	(1) ED duration (>4 hours) Ambulance	(2) ED duration (>4 hours) Non-Amb	(3) Hosp. adm. from ED Ambulance	(4) Hosp. adm. from ED Non-Amb	(5) 30-days reattendance Ambulance	(6) 30-days reattendance Non-Amb
Age 80-85	1.010	1.111***	1.059***	1.169***	1.015	1.038***
	(0.994-1.027)	(1.092-1.131)	(1.042-1.076)	(1.151-1.187)	(0.996-1.034)	(1.018-1.058)
Age 85-90	1.017**	1.219***	1.109***	1.371***	1.056***	1.122***
	(1.0003-1.035)	(1.196-1.243)	(1.090-1.127)	(1.348-1.394)	(1.036-1.077)	(1.099-1.146)
Age 90-95	1.029***	1.290***	1.142***	1.517***	1.073***	1.147***
	(1.009-1.049)	(1.258-1.322)	(1.120-1.165)	(1.485-1.550)	(1.049-1.097)	(1.117-1.178)
Age 95+	1.001	1.329***	1.084***	1.551***	1.063***	1.115***
	(0.971-1.032)	(1.275-1.386)	(1.052-1.117)	(1.493-1.610)	(1.027-1.101)	(1.065-1.167)
Sex (=1 male)	0.999	1.018**	1.091***	1.143***	1.110***	1.123***
	(0.987-1.011)	(1.004-1.033)	(1.077-1.104)	(1.129-1.157)	(1.095-1.126)	(1.106-1.140)
IMD2	0.989	0.990	0.998	0.997	0.976*	0.957***
	(0.966-1.013)	(0.962-1.018)	(0.976-1.022)	(0.973-1.023)	(0.951-1.002)	(0.929-0.987)
IMD3	0.978*	0.976*	1.019	1.004	0.975*	0.948***
	(0.956-1.0003)	(0.949-1.003)	(0.996-1.042)	(0.980-1.028)	(0.951-1.001)	(0.921-0.977)
IMD4	1.003	0.963**	1.023*	0.992	0.958***	0.905***
	(0.979-1.028)	(0.935-0.993)	(0.998-1.048)	(0.966-1.019)	(0.932-0.985)	(0.876-0.935)
IMD5	0.979*	0.980	1.007	0.973**	0.919***	0.910***
	(0.955-1.003)	(0.952-1.009)	(0.983-1.032)	(0.949-0.998)	(0.893-0.945)	(0.883-0.939)
IMD6	0.979*	0.941***	1.032***	0.910***	0.889***	0.914***
	(0.956-1.002)	(0.915-0.968)	(1.008-1.057)	(0.888-0.933)	(0.865-0.914)	(0.887-0.942)
IMD7	0.966***	0.949***	1.032***	0.934***	0.884***	0.878***
	(0.943-0.989)	(0.922-0.976)	(1.008-1.057)	(0.911-0.957)	(0.860-0.908)	(0.852-0.906)
IMD8	0.964***	0.930***	0.996	0.900***	0.863***	0.888***
	(0.940-0.989)	(0.903-0.958)	(0.971-1.021)	(0.877-0.923)	(0.838-0.888)	(0.861-0.917)
IMD9	0.981	0.932***	0.997	0.893***	0.870***	0.868***
	(0.956-1.007)	(0.905-0.960)	(0.971-1.023)	(0.870-0.916)	(0.844-0.896)	(0.840-0.896)
IMD10 - least deprived	0.964***	0.906***	0.973*	0.858***	0.845***	0.880***
	(0.937-0.991)	(0.876-0.937)	(0.947-1.001)	(0.833-0.884)	(0.818-0.873)	(0.849-0.914)
Care Home (=1 yes)	1.029***	1.168***	0.716***	1.067***	0.989	1.059***
	(1.014-1.045)	(1.143-1.193)	(0.705-0.727)	(1.047-1.087)	(0.973-1.006)	(1.035-1.083)
Road travel distance (min)	0.998***	1.004***	1.001***	1.008***	0.994***	0.992***
	(0.997-0.999)	(1.003-1.005)	(1.001-1.002)	(1.008-1.009)	(0.993-0.995)	(0.992-0.993)
Num. previous ED att. =1	1.034***	1.038***	1.069***	1.137***	1.388***	1.476***
	(1.018-1.050)	(1.019-1.056)	(1.053-1.085)	(1.120-1.154)	(1.363-1.414)	(1.448-1.505)
Num. previous ED att. =2	1.051***	1.067***	1.079***	1.234***	1.768***	1.899***
	(1.032-1.070)	(1.042-1.091)	(1.060-1.100)	(1.210-1.259)	(1.731-1.805)	(1.855-1.945)
Num. previous ED att. =3+	1.025***	1.143***	0.988	1.326***	3.010***	3.248***
	(1.008-1.042)	(1.119-1.168)	(0.972-1.004)	(1.302-1.351)	(2.957-3.064)	(3.181-3.315)
Length NHS111 call (min)	0.999	0.992***	0.994***	0.979***	0.999	0.992***
	(0.998-1.003)	(0.989-0.994)	(0.994-0.995)	(0.977-0.981)	(0.999-1.001)	(0.989-0.994)
NHS111 calls per day (>1)	1.078**	0.694**	0.977	0.898	1.084**	0.918
	(1.015-1.145)	(0.519-0.926)	(0.918-1.039)	(0.703-1.147)	(1.012-1.161)	(0.681-1.238)
Ambulance calls per day (>1)	1.100***		1.311***		1.101***	
	(1.069-1.132)		(1.273-1.351)		(1.065-1.137)	
CH desig. - urgent	1.059***		1.347***		1.008	
	(1.029-1.090)		(1.322-1.373)		(0.975-1.042)	
CH desig. - emergency	1.058***		1.379***		1.004	
	(1.042-1.073)		(1.360-1.399)		(0.988-1.021)	
CH desig. - life-threatening	1.076**		1.640***		0.913**	
	(1.008-1.148)		(1.537-1.751)		(0.843-0.990)	
Time ambulance on scene (min)	1.003***		1.008***		1.001***	
	(1.002-1.003)		(1.008-1.008)		(1.0002-1.001)	
Time from ambulance call to ED arrival (min)	1.001***		1.001***		1.0004***	
	(1.001-1.002)		(1.0003-1.001)		(1.0002-1.001)	
Out of Hours (=1 yes)	1.223***	1.513***	1.039***	1.480***	1.038***	1.112***
	(1.206-1.241)	(1.486-1.540)	(1.024-1.054)	(1.457-1.503)	(1.021-1.055)	(1.090-1.133)
Site size in 1,000	1.138***	1.079***	0.857***	0.877***	1.012***	1.009**
	(1.130-1.147)	(1.067-1.091)	(0.852-0.862)	(0.871-0.882)	(1.006-1.019)	(1.0002-1.018)
Number att. per cons.	0.999	0.999***	0.999***	1.0001***	1.00004**	1.00002
	(0.999-1.00002)	(0.999-0.999)	(0.999-0.999)	(1.00003-1.0001)	(1.00001-1.0001)	(0.999-1.0001)
Var(j)	0.819***	0.803***	0.637***	0.701***	0.006***	0.012***
	(0.227-1.361)	(0.280-1.327)	(0.216-1.057)	(0.240-1.163)	(0.002-0.011)	(0.004-0.019)
N	523,247	466,925	523,506	467,139	523,277	466,952
Sites	18	18	18	18	18	18
Time Fixed-Effects	Yes	Yes	Yes+	Yes+	Yes	Yes
Random-Effects levels	Site & patient	Site & patient	Site & patient	Site & patient	Site & patient	Site & patient
Years	2012-2017	2012-2017	2012-2017	2012-2017	2012-2017	2012-2017

Notes: See note to Table 1 for abbreviations. Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Odds ratios reported and 95% CI in parentheses. Var(j) reports the estimate and the 95% CI in parentheses. Model 5 and 6 (30-day re-attendance) include death as a covariate. Reference categories: Age 75-79, Female, IMD1 - most deprived, Previous ED attendances=0, No care home, NHS111 calls per <1, Ambulance (999) per day <1, CH designation - less-urgent, No Out of Hours. +financial year dummies not included.

Table A5: Multilevel model - ED outcomes' results sub-group analysis (Admitted to hospital vs Non-admitted to hospital): ED duration. - 2012-2017.

Dep var:	(1)	(2)
	ED duration ($>$4 hours)	
	Admitted to hospital	Non-admitted to hospital
Age 80-85	1.010	1.077***
	(0.995-1.016)	(1.055-1.099)
Age 85-90	1.010	1.153***
	(0.993-1.026)	(1.128-1.179)
Age 90-95	1.014	1.200***
	(0.995-1.033)	(1.168-1.232)
Age 95+	0.976	1.276***
	(0.946-1.006)	(1.223-1.331)
Sex (=1 male)	0.979***	1.004
	(0.967-0.991)	(0.988-1.021)
IMD2	0.978*	1.003
	(0.956-1.001)	(0.973-1.035)
IMD3	0.969***	0.993
	(0.948-0.991)	(0.963-1.024)
IMD4	0.989	0.990
	(0.965-1.013)	(0.958-1.023)
IMD5	0.981	0.977
	(0.958-1.004)	(0.946-1.010)
IMD6	0.970***	0.968**
	(0.948-0.993)	(0.939-0.999)
IMD7	0.963***	0.962**
	(0.941-0.986)	(0.932-0.993)
IMD8	0.965***	0.951***
	(0.941-0.989)	(0.920-0.983)
IMD9	0.964***	0.970*
	(0.941-0.989)	(0.938-1.004)
IMD10 - least deprived	0.962***	0.930***
	(0.936-0.989)	(0.896-0.965)
Care Home (=1 yes)	1.059***	1.209***
	(1.043-1.076)	(1.183-1.235)
Road travel distance (min)	0.998***	1.003***
	(0.997-0.999)	(1.002-1.004)
Num. previous ED attendances =1	1.010	1.041***
	(0.995-1.025)	(1.020-1.062)
Num. previous ED attendances =2	1.012	1.080***
	(0.994-1.031)	(1.053-1.108)
Num. previous ED attendances =3+	1.004	1.137***
	(0.988-1.021)	(1.112-1.163)
Length NHS111 call (min)	1.001***	0.999**
	(1.0003-1.002)	(0.997-0.999)
NHS111 calls per day ($>$1)	1.152***	0.889**
	(1.072-1.237)	(0.796-0.992)
Ambulance calls per day ($>$1)	1.063***	1.121***
	(1.027-1.099)	(1.058-1.188)
CH designation - less-urgent	0.882***	1.311***
	(0.860-0.905)	(1.266-1.358)
CH designation - urgent	0.923***	1.610***
	(0.894-0.952)	(1.542-1.682)
CH designation - emergency	0.896***	1.436***
	(0.876-0.917)	(1.387-1.487)
CH designation - life-threatening	0.890***	1.642***
	(0.826-0.959)	(1.444-1.868)
Time ambulance on scene (min)	1.002***	1.002***
	(1.001-1.002)	(1.002-1.003)
Time from ambulance call to ED arrival (min)	1.002***	1.002***
	(1.001-1.002)	(1.001-1.002)
Out of Hours (=1 yes)	1.170***	1.562***
	(1.154-1.187)	(1.532-1.593)
Site size in 1,000	1.182***	1.045***
	(0.1.173-1.191)	(1.024-1.066)
Number attendances per consultant	1.0001***	0.999***
	(1.0001-1.0001)	(0.999-0.999)
Var(j)	0.870***	1.063***
	(0.301-1.439)	(0.368-1.758)
N	571,897	418,275
Sites	18	18
Time Fixed-Effects (day, month, financial year)	Yes	Yes
Random-Effects levels	Site & patient	Site & patient
Years	2012-2017	2012-2017

Notes: See note to Table 1 for abbreviations. Significance levels: *** p$<$0.01, ** p$<$0.05, * p$<$0.1. Odds ratios reported and 95% CI in parentheses. Var(j) reports the estimate and the 95% CI in parentheses. Reference categories: Age 75-79, Female, IMD1 - most deprived, Previous ED attendances=0, No care home, NHS111 calls per $<$1, Ambulance (999) per day $<$1, No call to 999, No Out of Hours.
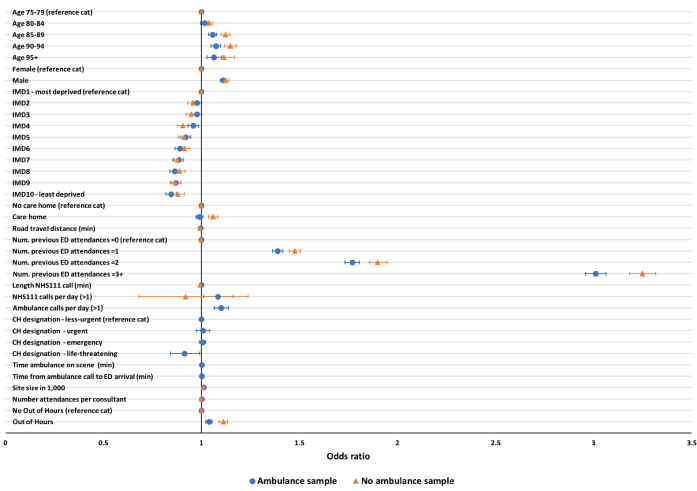
Figure A3: ED outcomes estimates ambulance vs no ambulance - (2012-2017)
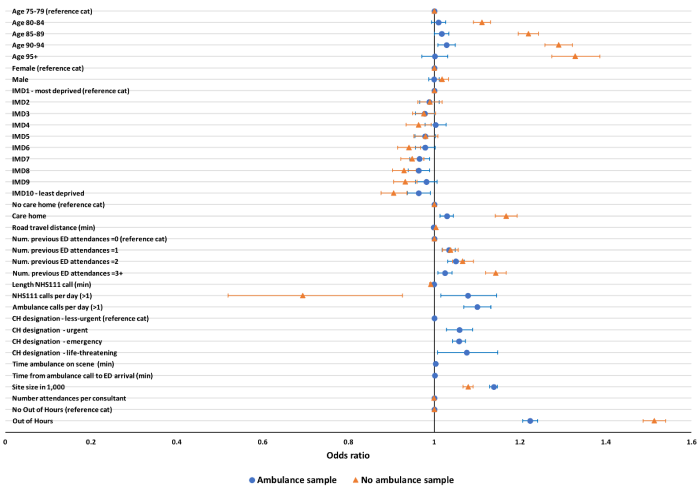
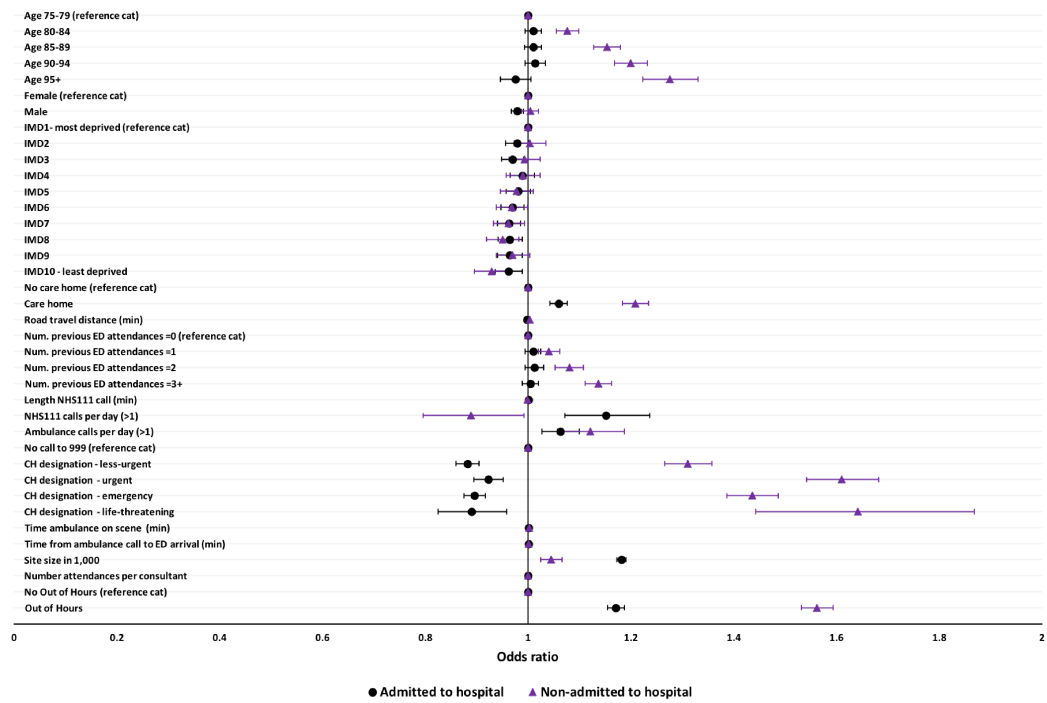(I) - ED duration (>4 hours)
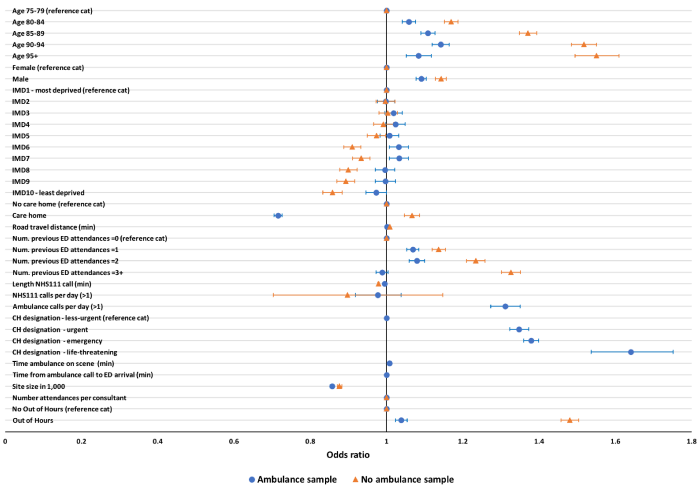
(II) - Hospital admission from ED

(III) - ED reattendance within 30 days

Notes: See note to Table 1 for abbreviations.

11

Figure A4: ED duration (>4 hours). Admitted to hospital vs Non-admitted to hospital

Notes: See note to Table 1 for abbreviations.

Supplemental material

BMJ Publishing Group Limited (BMJ) disclaims all liability and responsibility arising from any reliance
placed on this supplemental material which has been supplied by the author(s)

Emerg Med J

References

[1] Lewis J, Stone T, Simpson R, Jacques R, O'Keeffe C, Croft S, et al. Patient compliance with NHS 111 advice: Analysis of adult call and ED attendance data 2013–2017. Plos ONE. 2021;16(5):e0251362.

[2] Ministry of Housing, Communities and Local Government. The English indices of deprivation 2015;. Accessed June 12, 2020 [Online]. Available from: `https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015`.

[3] Bankart MJ, Baker R, Rashid A, Habiba H, Banerjee J, Hsu R, et al. Characteristics of general practices associated with emergency admission rates to hospital: a cross-sectional study. Emergency Medicine Journal. 2011;28(7):558-63.

[4] Yorkshire Ambulance Service NHS Trust. What happens when you call 999?;. Accessed Apr. 19, 2022 [Online]. Available from: `https://www.yas.nhs.uk/our-services/emergency-ambulance-service-999/what-happens-when-you-call-999/`.

[5] Walker AS, Mason A, Quan TP, Fawcett NJ, Watkinson P, Llewelyn M, et al. Mortality risks associated with emergency admissions during weekends and public holidays: an analysis of electronic health records. The Lancet. 2017;390(10089):62-72.

[6] NHS Digital. NHS workforce statistics;. Accessed Apr. 19, 2022 [Online]. Available from: `https://digital.nhs.uk/data-and-information/publications/statistical/nhs-workforce-statistics`.

[7] Keogh B, Culliford D, Guerrero-Ludueña R, Monks T. Exploring emergency department 4-hour target performance and cancelled elective operations: a regression analysis of routinely collected and openly reported NHS trust data. BMJ Open. 2018;8(5).

[8] Friebel R, Juarez RM. Spill Over Effects of Inpatient Bed Capacity on Accident and Emergency Performance in England. Health Policy. 2020;124(11):1182-91.

[9] Gaughan J, Kasteridis P, Mason A, Street A. Why are there long waits at English emergency departments? The European Journal of Health Economics. 2020;21(2):209-18.

[10] NHS England. Bed availability and occupancy;. Accessed Apr. 19, 2022 [Online]. Available from: `https://www.england.nhs.uk/statistics/statistical-work-areas/bed-availability-and-occupancy`.