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Risk factors for admission at three, urban Emergency Departments in England: a cross-sectional analysis of attendances over one month

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<ABSTRACT>

Objective: to investigate factors associated with unscheduled admission following presentation to Emergency Departments (EDs) at three hospitals in England.

Design and setting: cross-sectional analysis of attendance data for patients from three urban EDs in England: a large teaching hospital and major trauma centre (Site 1), and two district general hospitals (Sites 2 and 3). Variables included: patient age, gender, ethnicity, deprivation score, arrival date and time, arrival by ambulance or otherwise, a variety of ED workload measures, inpatient bed occupancy rates and admission outcome. Coding inconsistencies in routine ED data used for this study meant that diagnosis could not be included.

Outcome measure: The primary outcome for the study was unscheduled admission.

Participants: all adults aged 16 and over attending the three inner London EDs in December 2013. Data on 19,734 unique patient attendances were gathered.

Results: outcome data were available for 19,721 attendances (>99%), of whom 6,263 (32%) were admitted to hospital. Site 1 was set as the baseline site for analysis of admission risk. Risk of admission was significantly greater at Sites 2 and 3 (AOR relative to Site 1 for Site 2 was 1.91, 95% CI 1.76-2.07, p<0.001), and for patients of black or black British ethnicity (1.28, 1.14-1.42, p<0.001). Deprivation was strongly associated with admission. Analysis of departmental and hospital-wide workload pressures gave conflicting results, but proximity to the "four-hour target" (a rule that limits patient stays in EDs to four hours in the NHS in England) emerged as a strong driver for admission in this analysis (3.61, 3.30-3.95, p<0.001).

Conclusion**:** this study found statistically significant variations in odds of admission between hospital sites when adjusting for various patient demographic and presentation factors, suggesting important variations in ED- and clinician-level behaviour relating to admission decisions. The four-hour target is a strong driver for emergency admission.

<STRENGTHS AND LIMITATIONS OF THIS STUDY>

- Emergency admissions account for a substantial and growing proportion of hospital bed days in England, but while previous research has identified age, ethnicity, comorbidity, socio-economic status, sex, and referral source as factors influencing risk of admission following emergency attendance, organisational factors including Emergency Department (ED) workload and staffing have not been widely investigated.
- This study is among the first to investigate emergency admission patterns using routinely gathered ED data, incorporating patient demographic factors, ED workload factors and inpatient bed occupancy rates.
- The use of routine ED data in this analysis exposed problems with coding and definitions in electronic record systems, particularly relating to patient diagnosis which was ultimately excluded from the analysis. This may have an important bearing on admission risk and is a limitation to this study.
- The analysis demonstrates marked variations in risk of admission between EDs despite adjustment for a range of patient demographic and organisational factors. The proportion of patients who leave without receiving treatment at each time point emerges as a strong predictor of admission risk, as does disposition decision-making immediately before the four-hour target for EDs in England.

INTRODUCTION

Emergency admissions – defined as unpredicted admissions at short notice because of clinical need – account for around 67% of hospital bed days in England [1]. Avoiding such admissions, especially for conditions thought appropriate for non-emergent ambulatory pathways, is a priority for the National Health Service (NHS). This is because of significantly increased associated costs, negative impacts of unscheduled admissions on elective care and the risk to inpatients from nosocomial infections and venous thromboembolic disease. However, the upward trend in admission rates in England in recent years has been marked, rising by 5.2% between 2013 and 2014 alone [2, 3, 4].

The reasons for rising admission rates from Emergency Departments (EDs) remain poorly understood. Previous research aimed at identifying groups of patients at increased risk of admission has demonstrated significant associations between age, sex, ethnicity, presence of comorbid conditions, socio-economic indices (deprivation may explain up to 45% of the variation in ED admission rates between General Practices in England), and risk of emergency admission [2, 5, 6, 7]. These findings have prompted the development of increasingly sophisticated predictive tools to identify patients at high risk of admission and re-admission [8, 9, 10]. However, focusing on patients who frequently attend ED and on hospital re-admissions may overestimate the contribution of a relatively small group to the rising burden of emergency admissions overall – when most admissions actually come from lower risk groups [11]. The influence of changing models of delivery in primary and urgent care – including out-of-hours care, telemedicine, and case management among many others – has been investigated without evidence of a clear effect on ED admission rates [12, 13, 14], although poor continuity of primary care, and clinician behaviour have both emerged as possible factors in increased admission rates from primary care [15, 16].

By contrast, factors that may affect a patient's risk of admission on presentation to the ED have received very little attention. Clinician behaviour in the ED context is addressed by a small number of studies from Canada and the United States [17, 18]. Similarly, the operational and organisational features of an ED that may contribute to admission risk have been poorly studied, although there is some evidence that the four-hour target – a policy introduced in England in 2004 to limit patients' time in ED's to four hours – has led to a rise in short-stay admissions [19]. There is also evidence that levels of ED crowding increase rates of admission [20]. Evidence on the effect of other workload factors on emergency admission is conflicting, although higher inpatient bed occupancy may reduce the probability of admission [21].

To help build our understanding of the relative contributions of patient, clinician and organisational factors to emergency admission rates, we conducted an analysis of the factors involved in clinician decisions to admit (both long- and short-stay) or discharge ED attenders in three inner-city EDs in London. This paper presents the results of a cross-sectional analysis of a sample of all presentations across the three EDs over a period of one calendar month (December), which was conducted to quantify the effect of a selection of a patient and organisational factors on the outcome of each presentation (i.e. admission or discharge). This is accompanied by a linked qualitative study [22] exploring organisational factors affecting admission rates in more depth.

METHODS

Study sites

This was a cross-sectional observational study examining routinely collected data on all ED attendances at three inner-city EDs in London. Site 1 is a major, urban teaching hospital (a major trauma centre, equivalent to a level 1 trauma centre, with a hyper-acute stroke unit) while Sites 2 and 3 are urban, district general hospitals. Of these three sites, Sites 1 and 2 have formal ED Clinical Decision Units (CDUs) to accommodate short stay admissions (typically less than 24 hours), while Site 3 has an "Observational Unit" shared between the ED and various inpatient

specialties for short stay admissions. For the purposes of this study, admission to the Observational Unit at Site 3 was regarded as equivalent to admission to the CDUs at Site 1 and Site 2 (see below). All three sites have associated General Practitioner and specialist nurse staffed Urgent Care Centres, which see and filter a large volume of lower acuity presentations. Key characteristics of each department are outlined in Table 1.

Site	Number of adult beds – A&E Department	Number of adult beds and chairs – Clinical Decision Unit	Consultant staffing level
Site 1	38	14	24-hour, on-site
Site 2	37	12	8am-midnight, 7 days a week
Site 3	23	25	8am-8.30pm weekdays 10am-6pm weekends

Table 1: key characteristics of the three sites included in this study

Data collection

The study population consisted of all ED attendees aged 16 and over presenting in December 2013, including both ambulatory and ambulance service presentations. We collected basic demographic information (patient age, gender, ethnicity), arrival date & time, day of the week, whether the patient had arrived by ambulance or by another means, referral source, the final ED diagnosis, length of stay, whether the patient remained in the ED for longer than four hours, and the admission outcome. Supplementary data for patients admitted to the CDU included discharge date and time, and diagnosis on discharge.

Extensive data transformation was performed prior to analysis. Patient age data were converted into three banded age groups – 16-34, 35-64 and 65 and over. Ethnicity codes across the three sites were re-coded into six categories (Asian or Asian British, black or black British, mixed background, white, Unknown and Other). Deprivation scores were derived for each individual based on postcode data and use of the Index of Multiple Deprivation 2010, and then assigned a quintile score based on rankings across the three sites (Table 2) [23]. Outcome data relating to admission to the Observational Unit at Site 3 were adjusted by recoding those patients identified as "Admitted as Inpatient" (admission outcome) and "A&E" (admitting team) or "Obs Unit" (admission location) and re-labelling them as CDU admissions, to bring them into line with the other two sites.

Generation of proxy variables for ED workload, hospital workload, and staffing levels

Various proxy measures of for ED workload have been developed and some validated, but consensus on the most robust measures of crowding does not yet exist [24, 25, 26]. Thus a range of derived measures were included to test the strength of association with admission or discharge, using arrival time data to derive measures at each hour during the day throughout the month, as outlined in Table 2.

For each patient, the value for each of these variables corresponding to the patient arrival time was selected as the proxy for ED workload during their time in the department. Inpatient bed occupancy rate by day of arrival at each site was also incorporated (hourly data were not available). Finally, staffing information for each site (table 1) was used to derive a variable for the presence or absence of a consultant on duty (consultant present or absence). Additional workforce variables capturing, for instance, junior doctor staffing rates, were not included.

Outcomes

The single outcome of interest in this analysis was emergency admission (both inpatient and CDU), which was coded as a binary variable.

Variable	Variable type	Definition
Index of Multiple Deprivation (IMD) Score	Categorical	Quintile 1 (least deprived) – IMD score <24.94 Quintile 2 – IMD score 24.94-34.75 Quintile 3 – IMD score 34.76-41.05 Quintile 4 – IMD score 41.06-48.33 Quintile 5 (most deprived) – IMD score >48.33
ED bed occupancy rate	Continuous	Ratio of patients in the department in any given hour during the day, to the number of adults beds in the ED (see table 1)
Arrival intensity	Continuous	Raw number of patients arriving in the department during each hour of the day
Ambulance arrival intensity	Continuous	Ratio of patients arriving in the department by ambulance in any given hour, to the total number of patients arriving in that hour
"Left without being treated" (LWBT)	Continuous	Number of patients who left without treatment in any given hour as a proportion of all those leaving within the same hour
Late discharge	Binary	Positive score (1) applied to each patient who left the department between 230 and 240 minutes of initial attendance time. This measure was derived to investigate the impact of the four hour quality indicator on admission
Inpatient bed occupancy rate	Continuous	Proportion of general and acute medical beds occupied within each hospital, each day of the month. Figures are reported at 9am every day
Consultant on duty	Binary	Positive score (1) applied to each record for which a Consultant was on duty at the time of arrival in the ED

Table 2: definitions for derived variables for ED and hospital workload, and staffing factors, used in this analysis

Analysis

Data were summarised using simple cross-tabulations and odds ratios (ORs) calculated from these tables including adjustment for confounders to identify potential associations of interest. Data were then analysed in IBM SPSS Statistics v22.0, with binary logistic regression used to estimate adjusted ORs (AORs) for the single outcome variable identified above, in two models as follows:

- Model 1: risk of admission adjusted for potential patient demographic and arrival mode confounders (gender, age, ethnicity, deprivation quintile, arrival by ambulance or otherwise, site and shift during which the patient arrived). We used white British as the reference ethnic group for regression analyses.
- Model 2: risk of admission adjusting for the staffing and workload measures outlined above, in addition to the patient variables listed in model 1.

RESULTS

Descriptive statistics

The dataset comprised 19,734 unique patient attendances, for which some basic descriptive statistics are summarised in Tables 3 and 4 below. Of these unique attendances, 844 (4%) were coded as either "unplanned" or "planned" follow-up attendances, and on average 8% of patients at each site attended on more than one occasion in a calendar month.

Most of these presentations (66%) occurred during day shifts, defined as covering a time of arrival between 8am and 8pm. There was some variation in attendance rates across the week with higher attendance on Monday, Tuesday and Sunday at all three sites. A greater proportion (44%) of patients arrived at site 2 by ambulance, compared with sites 1 and 2 (30% and 36% respectively). Age bands for the patients presenting showed a skew towards younger age groups compared to national data, which is consistent with the urban and mobile populations of the areas served by

the three sites, although the age profile at site 2 is notably older at site 2, with 31% in the "65 and over" age group compared with 14% and 16% at sites 1 and 3 respectively.

Ethnicity data were available for 19,721 (over 99%) of the attendances and demonstrated predominantly white or white British populations (46% of all attendances) but with significant Asian or Asian British populations across all three sites (27% of all attendances). One (Site 3) showed black or black British patients forming a much larger proportion (17%) compared to the other two (9% and 11% respectively for Sites 1 and 2).

Diagnoses were available for all unique attendances, but of these, a substantial proportion (over 20%) described either patient disposition (e.g. "admission to inpatient care", "venous thromboembolism risk assessment") or were not diagnoses but rather body sites or symptoms (e.g. "abdomen", "knee" or "chest pain"). This varied considerably between sites. For example, the code "admission to inpatient care" accounted for 32% of final ED diagnoses in Site 3, compared with 0.02% at Site 2. For this reason ED diagnosis was not included in the regression analyses. Figure 1 shows the top ten diagnostic codes for attendances across all three sites, by age group following exclusion of disposition and codes describing body sites. The largest number of presentations across all sites and all age groups was for soft tissue injuries followed by abdominal pain, chest pain and back pain.

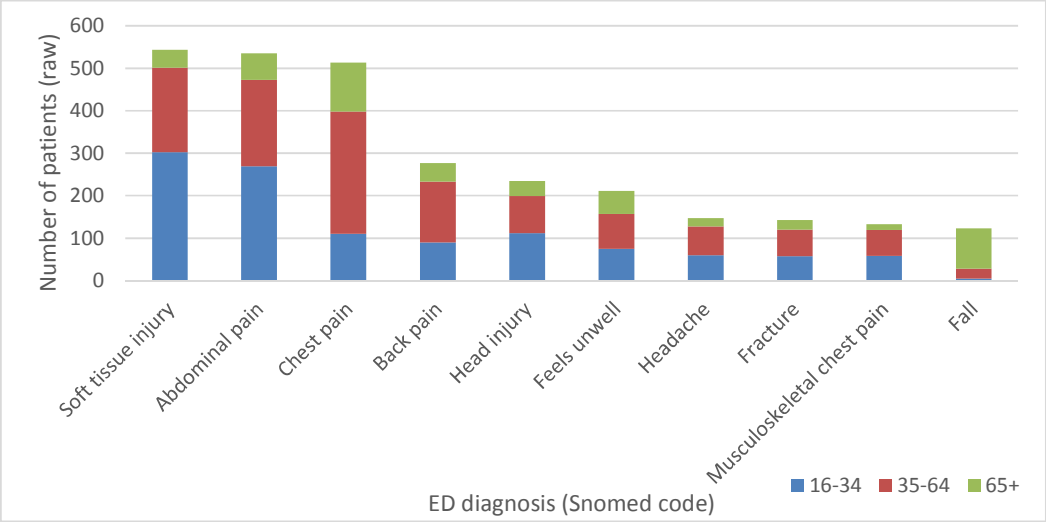

Figure 1: top 10 ED departure diagnosis codes, by age band, for December 2013

Descriptive statistics for the ED workload measures (continuous variables) generated are given in Table 4:

	Site 1		Site 2		Site 3		ALL	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ED bed occupancy rate	132%	46%	97%	32%	145%	53%	125%	48%
Arrival intensity	16	7	10	4	9	4	12.49	6.326
Ambulance arrival intensity	30%	16%	44%	19%	36%	21%	35%	19%
"Left without being treated" intensity	2%	5%	3%	6%	5%	9%	3%	7%
Inpatient bed occupancy rate	95%	3%	92%	4%	96%	3%	94%	4%

Table 3: descriptive statistics for ED workload factors, by site

Outcome data were available for every recorded attendance in the study period. Of the 19,734 unique attendances, 6,263 (around 32%) resulted in admission, but with large differences in outcome across the three sites, with around 43% of all presentations resulting in inpatient admission at Site 2, as opposed to 23% at Site 1 and 33% at Site 3.

			Site 1		Site 2		Site 3		All sites	
			Number of patients	Percentage of patients at this site	Number of patients	Percentage of patients at this site	Number of patients	Percentage of all patients	Number of patients	Percentage of patients at this site
ARRIVAL MARKERS	Time of arrival	Weekday (Mon-Fri)	2459	27%	1677	30%	1494	29%	5630	29%
		Weekend (Sat-Sun)	6526	73%	3841	70%	3737	71%	14104	72%
		Night shift (8pm-8am)	2895	32%	1958	36%	1849	35%	6702	34%
		Day shift (8am-8pm)	6090	68%	3560	64%	3382	65%	13032	66%
	Arrival mode	Arrived by ambulance	2673	30%	2419	44%	1900	36%	6992	35%
PATIENT DEMOGRAPHICS	Gender	Male	4886	54%	2700	49%	2443	47%	10029	51%
		Female	4099	46%	2818	51%	2788	53%	9705	49%
	Age band	16-34	4399	49%	1746	32%	2421	46%	8566	44%
		35-64	3236	36%	2065	37%	1964	38%	7265	37%
		65 and over	1278	14%	1707	31%	846	16%	3831	20%
	Ethnicity	Asian or Asian British	2528	28%	1067	19%	1737	33%	5332	27%
		Black or black British	794	9%	593	11%	895	17%	2282	12%
		Mixed Background	125	1%	90	2%	72	1%	287	2%
		Other	1152	13%	391	7%	664	13%	2207	11%
		Unknown	279	3%	253	6%	0	0%	532	3%
		White	4099	46%	3123	57%	1859	36%	9081	46%
	Index of Multiple Deprivation quintile	1 (least deprived)	1666	19%	1813	33%	235	5%	3714	19%
		2	1444	16%	1408	25%	863	17%	3715	19%
		3	1469	16%	1038	19%	1208	23%	3715	19%
		4	1621	18%	557	10%	1538	29%	3716	19%
		5 (most deprived)	1965	22%	539	10%	1210	23%	3714	19%
DIAGNOSIS	Ambulatory Case Sensitive Condition		907	10%	696	13%	375	9%	1978	11%
DEPARTMENTAL FACTORS	Consultant on Duty		8985	100%	4475	81%	3327	63%	16787	85%
	Patient remained in the ED > 4 hours		786	9%	358	7%	203	4%	1347	7%
	Patient discharged		6875	77%	3118	56%	3478	67%	13471	68%
	Patient admitted		2110	24%	2400	44%	1753	34%	6263	32%
	Patient admitted in last 10 mins before 4H		1067	12%	1118	20%	957	18%	3142	16%
OUTCOME	Admitted (all)		2110	23%	2400	43%	1753	34%	6263	32%

Table 4: descriptive statistics for unique attendances, by site, for December 2013

			Model 1				Model 2			
			Adjusted OR	95% C.I. bounds		P value	Adjusted OR	95% C.I. bounds		P value
				Lower	Upper			Lower	Upper	
SITE		Site 1	1.00*				1.00*			
		Site 2	1.91	1.76	2.07	<.001	1.75	1.58	1.95	<.001
		Site 3	1.63	1.49	1.77	<.001	1.65	1.45	1.88	<.001
ARRIVAL FACTORS	Arrival time	Weekend	1.00*				1.00*			
		Weekday	1.00	0.93	1.08	.919	1.02	0.94	1.11	.647
		Arrival at night	1.00*				1.00*			
		Arrival during the day	0.99	0.92	1.06	.686	1.03	0.93	1.14	.567
	Arrival mode	Did not arrive by LAS	1.00*				1.00*			
		Arrival by LAS	2.93	2.73	3.15	<.001	2.67	2.46	2.88	<.001
PATIENT DEMOGRAPHIC FACTORS	Gender	Male	1.00*				1.00*			
		Female	1.17	1.10	1.25	<.001	1.18	1.10	1.27	<.001
	Age band	16-34	1.00*				1.00*			
		35-64	1.64	1.51	1.77	<.001	1.58	1.46	1.72	<.001
		65 and over	4.08	3.71	4.48	<.001	3.85	3.49	4.24	<.001
	Ethnicity	White British	1.00*				1.00*			
		Asian or Asian British	1.00	0.92	1.09	.955	0.98	0.89	1.07	.607
		Black or Black British	1.28	1.14	1.43	<.001	1.28	1.14	1.43	<.001
		Mixed	1.08	0.80	1.46	.600	1.07	0.79	1.45	.666
		Other	1.04	0.93	1.17	.478	1.02	0.91	1.15	.709
		Unknown	0.98	0.79	1.21	.847	0.96	0.78	1.19	.730
	IMD score	Quintile 1	1.00*				1.00*			
		Quintile 2	1.08	0.98	1.20	.133	1.09	0.98	1.22	.102
		Quintile 3	1.18	1.06	1.31	.002	1.18	1.06	1.31	.003
		Quintile 4	1.13	1.01	1.26	.030	1.13	1.01	1.27	.029
		Quintile 5	1.23	1.11	1.37	<.001	1.24	1.11	1.39	<.001
DIAGNOSIS	ACSC?	No	1.00*				1.00*			
		Yes	1.27	1.14	1.41	<.001	1.21	1.08	1.35	.001
ORGANISATIONAL FACTORS	Consultant on duty?	No	1.00*				1.00*			
		Yes					1.24	1.08	1.41	.002
	Admission in 10 mins prior to 4H?	No	1.00*				1.00*			
		Yes					3.61	3.30	3.95	<.001
	Workload measures	ED bed occupancy rate					0.82	0.73	0.92	.001
		Inpatient bed occupancy rate					0.84	0.30	2.32	.732
		Arrival intensity					1.00	0.99	1.01	.616

		LAS intensity		0.98	0.79	1.21	.833
		LWBT intensity		1.77	1.06	2.94	.028

Table 5: adjusted odds ratios for admission controlling for various factors, in two binary logistic regression models (* denotes reference category)

Binary logistic regression results are presented in Table 5. Analysis of patient factors revealed that those of black or black British ethnicity were significantly more likely to be admitted as inpatients when adjusting for all other factors (including hospital site); black or black British patients had an AOR for admission of 1.28 (95% CI 1.15-1.43, p<0.001) in model 1. Odds of admission for other ethnic groups were not found to be significantly greater than the baseline group (white) in this analysis. Age was strongly associated with admission outcome, with rising AORs for admission with increasing age. Female patients were marginally more likely to be admitted as inpatients in both models (AOR 1.17, 95% CI 1.09-1.25, p<0.001 in model 1). Increasing deprivation was strongly associated with higher risk of admission in this analysis. Analysis of patient presentation factors demonstrated greatly increased odds of admission if a patient arrived by ambulance (2.99, 2.79-3.21 p<0.001 in model 1). Neither arrival day (weekday vs weekend) nor shift exerted a significant effect in model 1 or 2. However, arrival by ambulance was a strong predictor of admission (2.93, 2.73-3.15, p<0.001 in model 1). Patients presenting with an ACSC were at greater risk of inpatient admission when compared with all other presentations and adjusting for other factors (AOR 1.27, 1.14-1.41, p<0.001).

Results relating to organisational factors in model 2 demonstrated statistically significant differences in AORs for admission by site, with odds of admission being greater at Sites 2 and 3 than Site 1 (and particularly so for Site 2 – AOR 1.91, 1.76-2.07, p<0.001 in model 1). This observation held even when controlling for departmental load factors in model 2 (AOR for Site 2 was greatest in both models: 1.75 in model 2, 1.58-1.95, p<0.001). However, analysis of various workload-related factors gave conflicting results in respect of admission risk. In this analysis, both LWBT intensity (1.77, 1.06-2.94, p<0.05) and particularly disposition decision in the 10 minutes leading up to the four-hour target (3.61, 3.30-3.95, p<0.001) were markers of risk of emergency admission. By contrast, high ED bed occupancy rate marginally reduced the risk of admission (0.82, 0.73-0.92, p=0.001), while arrival intensity (both in total and by ambulance alone) and inpatient bed occupancy rate had no discernible effect on admission risk. In this analysis, presence of a consultant conferred an increase in risk of admission when controlling for other factors (1.24, 1.08-1.41, p<0.05).

DISCUSSION

This cross-sectional analysis of attendance data from three EDs in England is among the first to use routine ED data to develop a multi-dimensional view of patient-related, presentational and department workload factors that may influence admission decision-making. We found statistically significant differences in odds of admission between sites which could not be explained by a range of patient demographic, patient presentation and workload-related factors. Explanations for the magnitude of the difference in admission risk between sites are not immediately apparent. Although a greater proportion of patients attending at site 2 arrived by ambulance and were in the oldest age group (65 and over), odds of admission remain significantly different between sites even when controlling for these variables. However, our accompanying qualitative analysis of organisational factors suggests that cultural factors may be important; respondents identified additional management pressures at site 2 and a less supportive environment for junior staff as important factors in explaining admission risk. Deconstructing the “cultural” factors that may contribute to admission risk is an important area for future research. Analysis of demographic factors in this study corroborates results from analyses elsewhere, notably the clear relationship between rising deprivation level and admission risk fits with findings from a range of other studies [4, 5, 7, 8, 9], and the increased risk of admission observed for patients of black or black British ethnicity, a strong association possibly reflecting the particular burden of chronic disease morbidity in these patients.

These findings suggest that other ED-related and clinician level behaviours may play an important role in admission rates. In particular, the strength of the observed relationship between late discharge (i.e. patients who leave the ED in the 10 minutes preceding the four-hour target and risk of admission suggests that the four-hour waiting time target for EDs in England influence decisions to admit. Clinicians may be admitting patients they had expected to

discharge, as they were unable to complete their diagnostic and/or therapeutic work up in the four-hour time frame. Conflicting findings from analysis using a variety of ED workload measures, some of which (e.g. LWBT intensity and ED bed occupancy rate) are regarded as well-validated measures suggest that caution should be exercised in using quantitative proxies for workload. Nevertheless, results suggest that knowledge of high bed occupancy in the ED may dissuade clinical teams from admitting patients, although no relationship with inpatient bed occupancy was demonstrated.

The use of routine ED data in this analysis exposed significant problems with coding and definitions that have been discussed elsewhere [27], and the absence of patient diagnosis and co-morbidity data is a major limitation. Both factors may have an important bearing on admission risk. However, the selection of three hospital sites serving similar parts of London where we would not expect to see systematic differences in the quality of primary care, and analysis of data on a large number of attendances (approaching 20,000) of varying acuities, suggests that patient case-mix is unlikely to fully account for the significant variation in admission risk observed between sites. Secondly, a subset of patients were identified as having presented on multiple occasions. For the purposes of this analysis, all attendances were treated as unique events and no supplementary analysis of repeat attenders with (potentially) linked attendance patterns was attempted. Thirdly, ED workload variables were generated for each patient at a single, fixed time-point and are therefore an approximation. This was particularly the case for inpatient bed occupancy rates, for which only daily bed occupancy rates for each site could be obtained. However, it also applies to measures such as consultant staffing, for which single estimates were generated based on the patient's time of arrival. This may have led to the analysis of some attendances as "consultant staffed", when in fact a consultant was not on duty when the decision to admit or discharge was made. The cross-sectional design of the study meant that it was not possible in this analysis to model ED workload factors as dynamic variables. Finally, the study would have benefited from analysis of a data over a longer time period, rather than a single, mid-winter month. Building a more complete picture of variations in risk over time is an important area for further research.

CONCLUSIONS

In this analysis, risk of inpatient admission was found to be significantly higher at two of the sites when compared with the first, adjusting for a variety of demographic, patient presentation and departmental factors. Risk of admission was also greater for those of black or black British ethnicity. Evidence on the role of ED workload factors was conflicting, but the four-hour target emerges as a strong driver for admission behaviour.

<DETAILS>

COMPETING INTERESTS: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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GUARANTOR: TH

CONTRIBUTORSHIP: IP, DM and TH initiated the project, designed the study and specified the data collection protocol. IP, RC, EG, RL and GJ collected the data. SAI cleaned and transformed the data, incorporated new variables and performed the statistical analysis. SAI and IP drafted and revised the manuscript. DM, BB and TH commented on and revised the manuscript.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	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
Introduction			
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
Methods			
Study design	4	Present key elements of study design early in the paper	4-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
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	5-6
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

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	6
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-8
		(b) Indicate number of participants with missing data for each variable of interest	7
Outcome data	15*	Report numbers of outcome events or summary measures	7
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	9
		(*b*) Report category boundaries when continuous variables were categorized	5-6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
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	10-11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-11
Other information			
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	12

*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.

BMJ Open

Risk factors for admission at three, urban Emergency Departments in England: a cross-sectional analysis of attendances over one month

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<TITLE PAGE>

TITLE: Risk factors for admission at three, urban Emergency Departments in England: a cross-sectional analysis of attendances over one month

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<ABSTRACT>

Objective: to investigate factors associated with unscheduled admission following presentation to Emergency Departments (EDs) at three hospitals in England.

Design and setting: cross-sectional analysis of attendance data for patients from three urban EDs in England: a large teaching hospital and major trauma centre (Site 1), and two district general hospitals (Sites 2 and 3). Variables included: patient age, gender, ethnicity, deprivation score, arrival date and time, arrival by ambulance or otherwise, a variety of ED workload measures, inpatient bed occupancy rates and admission outcome. Coding inconsistencies in routine ED data used for this study meant that diagnosis could not be included.

Outcome measure: The primary outcome for the study was unscheduled admission.

Participants: all adults aged 16 and over attending the three inner London EDs in December 2013. Data on 19,734 unique patient attendances were gathered.

Results: outcome data were available for 19,721 attendances (>99%), of whom 6,263 (32%) were admitted to hospital. Site 1 was set as the baseline site for analysis of admission risk. Risk of admission was significantly greater at Sites 2 and 3 (AOR relative to Site 1 for Site 2 was 1.89, 95% CI 1.74-2.05, p<0.001), and for patients of black or black British ethnicity (1.29, 1.16-1.44, p<0.001). Deprivation was strongly associated with admission. Analysis of departmental and hospital-wide workload pressures gave conflicting results, but proximity to the "four-hour target" (a rule that limits patient stays in EDs to four hours in the NHS in England) emerged as a strong driver for admission in this analysis (3.61, 3.30-3.95, p<0.001).

Conclusion**:** this study found statistically significant variations in odds of admission between hospital sites when adjusting for various patient demographic and presentation factors, suggesting important variations in ED- and clinician-level behaviour relating to admission decisions. The four-hour target is a strong driver for emergency admission.

<STRENGTHS AND LIMITATIONS OF THIS STUDY>

- Emergency admissions account for a substantial and growing proportion of hospital bed days in England, but while previous research has identified age, ethnicity, comorbidity, socio-economic status, sex, and referral source as factors influencing risk of admission following emergency attendance, organisational factors including Emergency Department (ED) workload and staffing have not been widely investigated.
- This study is among the first to investigate emergency admission patterns using routinely gathered ED data, incorporating patient demographic factors, ED workload factors and inpatient bed occupancy rates.
- The use of routine ED data in this analysis exposed problems with coding and definitions in electronic record systems, particularly relating to patient diagnosis which was ultimately excluded from the analysis. This may have an important bearing on admission risk and is a limitation to this study.
- The analysis demonstrates marked variations in risk of admission between EDs despite adjustment for a range of patient demographic and organisational factors. The proportion of patients who leave without receiving treatment at each time point emerges as a strong predictor of admission risk, as does disposition decision-making immediately before the four-hour target for EDs in England.

INTRODUCTION

Emergency admissions – defined as unpredicted admissions at short notice because of clinical need – account for around 67% of hospital bed days in England [1]. Avoiding such admissions, especially for conditions thought appropriate for non-emergent ambulatory pathways, is a priority for the National Health Service (NHS). This is because of significantly increased associated costs, negative impacts of unscheduled admissions on elective care and the risk to inpatients from nosocomial infections and venous thromboembolic disease. However, the upward trend in admission rates in England in recent years has been marked, rising by 5.2% between 2013 and 2014 alone [2, 3, 4].

The reasons for rising admission rates from Emergency Departments (EDs) remain poorly understood. Previous research aimed at identifying groups of patients at increased risk of admission has demonstrated significant associations between age, sex, ethnicity, presence of comorbid conditions, socio-economic indices (deprivation may explain up to 45% of the variation in ED admission rates between General Practices in England), and risk of emergency admission [2, 5, 6, 7]. These findings have prompted the development of increasingly sophisticated predictive tools to identify patients at high risk of admission and re-admission [8, 9, 10]. However, focusing on patients who frequently attend ED and on hospital re-admissions may overestimate the contribution of a relatively small group to the rising burden of emergency admissions overall – when most admissions actually come from lower risk groups [11]. The influence of changing models of delivery in primary and urgent care – including out-of-hours care, telemedicine, and case management among many others – has been investigated without evidence of a clear effect on ED admission rates [12, 13, 14], although poor continuity of primary care, and clinician behaviour have both emerged as possible factors in increased admission rates from primary care [15, 16].

By contrast, factors that may affect a patient's risk of admission on presentation to the ED have received very little attention. Clinician behaviour in the ED context is addressed by a small number of studies from Canada and the United States [17, 18]. Similarly, the operational and organisational features of an ED that may contribute to admission risk have been poorly studied, although there is some evidence that the four-hour target – a policy introduced in England in 2004 to limit patients' time in ED's to four hours – has led to a rise in short-stay admissions [19]. There is also evidence that levels of ED crowding increase rates of admission [20]. Evidence on the effect of other workload factors on emergency admission is conflicting, although higher inpatient bed occupancy may reduce the probability of admission [21].

To help build our understanding of the relative contributions of patient, clinician and organisational factors to emergency admission rates, we conducted an analysis of the factors involved in clinician decisions to admit (both long- and short-stay) or discharge ED attenders in three inner-city EDs in London. This paper presents the results of a cross-sectional analysis of a sample of all presentations across the three EDs over a period of one calendar month (December), which was conducted to quantify the effect of a selection of a patient and organisational factors on the outcome of each presentation (i.e. admission or discharge). This is accompanied by a linked qualitative study [22] exploring organisational factors affecting admission rates in more depth.

METHODS

Study sites

This was a cross-sectional observational study examining routinely collected data on all ED attendances at three inner-city EDs in London. Site 1 is a major, urban teaching hospital (a major trauma centre, equivalent to a level 1 trauma centre, with a hyper-acute stroke unit) while Sites 2 and 3 are urban, district general hospitals. Of these three sites, Sites 1 and 2 have formal ED Clinical Decision Units (CDUs) to accommodate short stay admissions (typically less than 24 hours), while Site 3 has an "Observational Unit" shared between the ED and various inpatient

specialties for short stay admissions. For the purposes of this study, admission to the Observational Unit at Site 3 was regarded as equivalent to admission to the CDUs at Site 1 and Site 2 (see below). All three sites have associated General Practitioner and specialist nurse staffed Urgent Care Centres, which see and filter a large volume of lower acuity presentations. Key characteristics of each department are outlined in Table 1.

Site	Average number of open general and acute inpatient beds during study period	Number of critical care beds	Number of adult beds – Emergency Department	Number of adult beds and chairs – Clinical Decision Unit	Consultant staffing level	Emergency Department attendances in the year 2012-13
Site 1	747	61	38	14	24-hour, on-site	92,137
Site 2	589	9	37	12	8am-midnight, 7 days a week	70,144
Site 3	452	7	23	25	8am-8.30pm weekdays 10am-6pm weekends	55,866

Table 1: key characteristics of the three sites included in this study, and annual emergency department attendance (attendance data drawn from [23])

Data collection

The study population consisted of all ED attendees aged 16 and over presenting in December 2013, including both ambulatory and ambulance service presentations. The selected time period for data collection was convenience-based. We collected basic demographic information (patient age, gender, ethnicity), arrival date & time, day of the week, whether the patient had arrived by ambulance or by another means, referral source, the final ED diagnosis, length of stay, whether the patient remained in the ED for longer than four hours, and the admission outcome. Data on acuity of patient presentation (in the form of triage scores by individual presentation) could not be obtained for this study. Supplementary data for patients admitted to the CDU included discharge date and time, and diagnosis on discharge. Data across the three sites were extracted independently by data collectors overseen and trained by the second author.

Extensive data transformation was performed prior to analysis. Patient age data were converted into four banded groups – 16-34, 35-64 and 65-84 and 85 and over. This approach was dictated partly by the need for parsimony in the number of categories within each predictor variable and differences in the distribution of patients by age group across the three study sites (the proportion of presenting patients in the 85 and over category at site 2 was more than three times greater than each of sites 1 and 3). Primarily, however, it was driven by clinical evidence on the prevalence of multimorbidity and frailty among the “oldest old” (85 and over), when compared with younger patients [24, 25], and rising emergency admission risk among older age groups [26]. Ethnicity codes across the three sites were re-coded into six categories (Asian or Asian British, black or black British, mixed background, white, Unknown and Other). Deprivation scores were derived for each individual based on postcode data and use of the Index of Multiple Deprivation 2010, and then assigned a quintile score based on rankings across the three sites (Table 2) [27]. Outcome data relating to admission to the Observational Unit at Site 3 were adjusted by recoding those patients identified as “Admitted as Inpatient” (admission outcome) and “A&E” (admitting team) or “Obs Unit” (admission location) and re-labelling them as CDU admissions, to bring them into line with the other two sites.

Generation of proxy variables for ED workload, hospital workload, and staffing levels

Various proxy measures of for ED workload have been developed and some validated, but consensus on the most robust measures of crowding does not yet exist [28, 29, 30]. Thus a range of derived measures were included to test

the strength of association with admission or discharge, using arrival time data to derive measures at each hour during the day throughout the month, as outlined in Table 2.

For each patient, the value for each of these variables corresponding to the patient arrival time was selected as the proxy for ED workload during their time in the department. Inpatient bed occupancy rate by day of arrival at each site was also incorporated (hourly data were not available). Finally, staffing information for each site (table 1) was used to derive a variable for the presence or absence of a consultant on duty (consultant present or absence). Additional workforce variables capturing, for instance, junior doctor and nurse staffing rates, were not included because the complexity of rotas could not readily be codified in variable form for a cross-sectional analysis.

Outcomes

The single outcome of interest in this analysis was emergency admission (both inpatient and CDU), which was coded as a binary variable.

Variable	Variable type	Definition
Index of Multiple Deprivation (IMD) Score	Categorical	Quintile 1 (least deprived) – IMD score <24.94 Quintile 2 – IMD score 24.94-34.75 Quintile 3 – IMD score 34.76-41.05 Quintile 4 – IMD score 41.06-48.33 Quintile 5 (most deprived) – IMD score >48.33
ED bed occupancy rate	Continuous	Ratio of patients in the department in any given hour during the day, to the number of adults beds in the ED (see table 1)
Arrival intensity	Continuous	Raw number of patients arriving in the department during each hour of the day
Ambulance arrival intensity	Continuous	Ratio of patients arriving in the department by ambulance in any given hour, to the total number of patients arriving in that hour
"Left without being treated" (LWBT)	Continuous	Number of patients who left without treatment in any given hour as a proportion of all those leaving within the same hour
Late discharge	Binary	Positive score (1) applied to each patient who left the department between 230 and 240 minutes of initial attendance time. This measure was derived to investigate the impact of the four hour quality indicator on admission
Inpatient bed occupancy rate	Continuous	Proportion of general and acute medical beds occupied within each hospital, each day of the month. Figures are reported at 9am every day
Consultant on duty	Binary	Positive score (1) applied to each record for which a Consultant was on duty at the time of arrival in the ED

Table 2: definitions for derived variables for ED and hospital workload, and staffing factors, used in this analysis

Analysis

Data were summarised in IBM SPSS Statistics v22.0 using simple cross-tabulations and odds ratios (ORs) calculated from these tables including adjustment for confounders to identify potential associations of interest. In order to exclude the possibility of significant multicollinearity between workload variables given the method by which these derived, diagnostic tests were performed in SPSS; no significant collinearity was demonstrated between them. Data were then analysed with binary logistic regression used to estimate adjusted ORs (AORs) for the single outcome variable identified above, in two models as follows:

- Model 1: risk of admission adjusted for potential patient demographic and arrival mode confounders (gender, age, ethnicity, deprivation quintile, arrival by ambulance or otherwise, site and shift during which the patient arrived). We used White British as the reference ethnic group for regression analyses.
- Model 2: risk of admission adjusting for the staffing and workload measures outlined above (with, again, White British used as the reference group for the ethnicity categorical variable), in addition to the patient variables listed in model 1. In view of uncertainty over the value of including different workload variables, a stepwise approach was taken to inclusion or exclusion of workload variables from the model, using a backward elimination approach in which only those variables with a p value less than 0.05 were retained.

RESULTS

Descriptive statistics

The dataset comprised 19,734 unique patient attendances, for which some basic descriptive statistics are summarised in Tables 3 and 4 below. Of these unique attendances, 844 (4%) were coded as either "unplanned" or "planned" follow-up attendances, and on average 8% of patients at each site attended on more than one occasion in a calendar month.

Most of these presentations (66%) occurred during day shifts, defined as covering a time of arrival between 8am and 8pm. There was some variation in attendance rates across the week with higher attendance on Monday, Tuesday and Sunday at all three sites. A greater proportion (44%) of patients arrived at site 2 by ambulance, compared with sites 1 and 2 (30% and 36% respectively). Age bands for the patients presenting showed a skew towards younger age groups compared to national data, which is consistent with the urban and mobile populations of the areas served by the three sites, although the age profile at site 2 is notably older at site 2, with 9% in the "oldest old" age group compared with 2% and 3% at sites 1 and 3 respectively. This observation may partially account for a higher proportion of arrivals by ambulance at site 2 when compared with the other sites.

Ethnicity data were available for 19,721 (over 99%) of the attendances and demonstrated predominantly white or white British populations (46% of all attendances) but with significant Asian or Asian British populations across all three sites (27% of all attendances). One (Site 3) showed black or black British patients forming a much larger proportion (17%) compared to the other two (9% and 11% respectively for Sites 1 and 2).

Diagnoses were available for all unique attendances, but of these, a substantial proportion (over 20%) described either patient disposition (e.g. "admission to inpatient care", "venous thromboembolism risk assessment") or were not diagnoses but rather body sites or symptoms (e.g. "abdomen", "knee" or "chest pain"). This varied considerably between sites. For example, the code "admission to inpatient care" accounted for 32% of final ED diagnoses in Site 3, compared with 0.02% at Site 2. For this reason ED diagnosis was not included in the regression analyses.

Descriptive statistics for the ED workload measures (continuous variables) generated are given in Table 4:

	Site 1		Site 2		Site 3		ALL	
	Median	IQR*	Median	IQR	Median	IQR	Median	IQR
ED bed occupancy rate	134%	63%	97%	41%	143%	74%	124%	68%
Arrival intensity	16	10	9	5	9	6	11	8
Ambulance arrival intensity	27%	19%	43%	26%	33%	28%	33%	24%
"Left without being treated" intensity	0%	0%	0%	0%	0%	8%	0%	0%
Inpatient bed occupancy rate	95%	2%	92%	5%	96%	4%	95%	5%

Table 3: descriptive statistics for ED workload factors, by site (*IQR = inter-quartile range)

Outcome data were available for every recorded attendance in the study period. Of the 19,734 unique attendances, 6,263 (around 32%) resulted in admission, but with large differences in outcome across the three sites, with around 43% of all presentations resulting in inpatient admission at Site 2, as opposed to 23% at Site 1 and 33% at Site 3.

			Site 1		Site 2		Site 3		All sites	
			Number of patients	Percentage of patients at this site	Number of patients	Percentage of patients at this site	Number of patients	Percentage of all patients	Number of patients	Percentage of patients at this site
ARRIVAL MARKERS	Time of arrival	Weekday (Mon-Fri)	6526	73%	3841	70%	3737	71%	14104	72%
		Weekend (Sat-Sun)	2459	27%	1677	30%	1494	29%	5630	29%
		Night shift (8pm-8am)	2895	32%	1958	36%	1849	35%	6702	34%
		Day shift (8am-8pm)	6090	68%	3560	64%	3382	65%	13032	66%
	Arrival mode	Arrived by ambulance	2673	30%	2419	44%	1900	36%	6992	35%
PATIENT DEMOGRAPHICS	Gender	Male	4886	54%	2700	49%	2443	47%	10029	51%
		Female	4099	46%	2818	51%	2788	53%	9705	49%
	Age band	16-34	4399	49%	1746	32%	2421	46%	8566	44%
		35-64	3236	36%	2065	37%	1964	38%	7265	37%
		65-84	1074	12%	1200	22%	667	13%	2941	15%
		85 and over	204	2%	507	9%	179	3%	890	5%
	Ethnicity	Asian or Asian British	2528	28%	1067	19%	1737	33%	5332	27%
		Black or black British	794	9%	593	11%	895	17%	2282	12%
		Mixed Background	125	1%	90	2%	72	1%	287	2%
		Other	1152	13%	391	7%	664	13%	2207	11%
		Unknown	279	3%	253	6%	0	0%	532	3%
		White	4099	46%	3123	57%	1859	36%	9081	46%
	IMD quintile	1 (least deprived)	1666	19%	1813	33%	235	5%	3714	19%
		2	1444	16%	1408	25%	863	17%	3715	19%
		3	1469	16%	1038	19%	1208	23%	3715	19%
		4	1621	18%	557	10%	1538	29%	3716	19%
		5 (most deprived)	1965	22%	539	10%	1210	23%	3714	19%
DIAGNOSIS	ACSC		907	10%	696	13%	375	9%	1978	11%
DEPARTMENTAL FACTORS	Consultant on Duty		8985	100%	4475	81%	3327	63%	16787	85%
	Patient remained in the ED > 4 hours		786	9%	358	7%	203	4%	1347	7%
	Patient discharged		6875	77%	3118	56%	3478	67%	13471	68%
	Patient admitted		2110	24%	2400	44%	1753	34%	6263	32%
	Patient admitted in last 10 mins before 4H		1067	12%	1118	20%	957	18%	3142	16%
OUTCOME	Admitted (all)		2110	23%	2400	43%	1753	34%	6263	32%

Table 4: descriptive statistics for unique attendances, by site, for December 2013 (IMD = Index of Multiple Deprivation; ACSC = Ambulatory Care Sensitive Condition)

		Model 1				Model 2			
			95% C.I.for EXP(B)				95% C.I.for EXP(B)		
		AOR	Lower	Upper	p-value	AOR	Lower	Upper	p-value
Site	Site 1	1.00*				1.00*			
	Site 2	1.89	1.74	2.05	<0.001	1.75	1.60	1.92	<0.001
	Site 3	1.62	1.48	1.77	<0.001	1.67	1.50	1.85	<0.001
Arrival time	Weekend	1.00*				1.00*			
	Weekday	1.01	0.93	1.09	.853	1.02	0.94	1.10	.687
	Arrival at night	1.00*				1.00*			
	Arrival during the day	0.98	0.91	1.05	.557	1.02	0.93	1.12	.732
Arrival mode	Did not arrive by LAS	1.00*				1.00*			
	Arrival by LAS	2.89	2.69	3.10	<0.001	2.63	2.44	2.83	<0.001
Gender	Male	1.00*				1.00*			
	Female	1.16	1.08	1.24	<0.001	1.17	1.09	1.25	<0.001
Age band	Age 16-34	1.00*				1.00*			
	Age 35-64	1.64	1.52	1.77	<0.001	1.58	1.46	1.71	<0.001
	Age 65-84	3.74	3.38	4.13	<0.001	3.52	3.17	3.90	<0.001
	Age 85+	5.90	4.96	7.02	<0.001	5.53	4.63	6.61	<0.001
Ethnicity	White British	1.00*				1.00*			
	Asian or Asian British	1.01	0.93	1.10	.796	.99	.91	1.08	.841
	Black or Black British	1.29	1.16	1.44	<0.001	1.29	1.15	1.44	<0.001
	Mixed	1.09	0.81	1.47	.551	1.08	.80	1.47	.607
	Other	1.05	0.94	1.18	.380	1.04	.93	1.17	.486
	Unknown	.99	.80	1.22	.892	.97	.78	1.20	.770
IMD score	Quintile 1	1.00*				1.00*			
	Quintile 2	1.09	0.98	1.21	.123	1.09	0.98	1.22	.108
	Quintile 3	1.18	1.06	1.32	.002	1.17	1.05	1.31	.004

	Quintile 4	1.13	1.01	1.26	.034	1.13	1.01	1.26	.039
	Quintile 5	1.24	1.11	1.38	<0.001	1.24	1.11	1.39	<0.01
Presence of ACSC	No ACSC	1.00*				1.00*			
	Has ACSC	1.27	1.14	1.41	<0.001	1.21	1.08	1.35	.001
Consultant on duty	No consultant on duty					1.00*			
	Consultant on duty					1.24	1.09	1.42	.001
Admission in 10 mins prior to 4H	Admitted before 3:50					1.00*			
	Admitted after 3:50					3.61	3.30	3.95	<0.001
Additional workload measures	ED bed occupancy rate					0.80	0.74	0.87	<0.001
	LWBT intensity					1.83	1.10	3.04	.020

Table 5: adjusted odds ratios for admission controlling for various factors, in two binary logistic regression models (* denotes reference category; IMD = Index of Multiple Deprivation; LAS = London Ambulance Service; ACSC = Ambulatory Care Sensitive Condition; LWBT = Left Without Being Treated)

Binary logistic regression results are presented in Table 5. Analysis of patient factors revealed that those of black or black British ethnicity were significantly more likely to be admitted as inpatients when adjusting for all other factors (including hospital site); black or black British patients had an AOR for admission of 1.29 (95% CI 1.16-1.44, p<0.001) in model 1. Odds of admission for other ethnic groups were not found to be significantly greater than the baseline group (white) in this analysis. Age was strongly associated with admission outcome, with rising AORs for admission with increasing age, especially among the "oldest old". Female patients were marginally more likely to be admitted as inpatients in both models (AOR 1.16, 95% CI 1.08-1.24, p<0.001 in model 1). Increasing deprivation was strongly associated with higher risk of admission in this analysis. Analysis of patient presentation factors demonstrated greatly increased odds of admission if a patient arrived by ambulance (2.89, 2.69-3.10 p<0.001 in model 1). Neither arrival day (weekday vs weekend) nor shift exerted a significant effect in model 1 or 2.. Patients presenting with an ACSC were at greater risk of inpatient admission when compared with all other presentations and adjusting for other factors (AOR 1.27, 1.14-1.41, p<0.001 in model 1).

Results relating to organisational factors in model 2 demonstrated statistically significant differences in AORs for admission by site, with odds of admission being greater at Sites 2 and 3 than Site 1 (and particularly so for Site 2 – AOR 1.89, 1.74-2.05, p<0.001 in model 1). This observation held even when controlling for departmental load factors in model 2 (AOR for Site 2 was greatest in both models: 1.75 in model 2, 1.60-1.92, p<0.001). However, analysis of various workload-related factors gave conflicting results in respect of admission risk. In this analysis, both LWBT intensity (1.83, 1.10-3.04, p<0.05) and particularly disposition decision in the 10 minutes leading up to the four-hour target (3.61, 3.30-3.95, p<0.001) were markers of risk of emergency admission. By contrast, high ED bed occupancy rate marginally reduced the risk of admission (0.80, 0.74-0.87, p=0.001). Arrival intensity (both in total and by ambulance alone) and inpatient bed occupancy rate had no discernible effect on admission risk and were removed from model 2 to improve fit. In this analysis, presence of a consultant conferred an increase in risk of admission when controlling for other factors (1.24, 1.08-1.41, p<0.05).

DISCUSSION

This analysis found statistically significant differences in odds of admission between sites which could not be explained by a range of patient demographic, patient presentation and workload-related factors. Explanations for the magnitude of the difference in admission risk between sites are not immediately apparent. Although a greater proportion of patients attending at site 2 arrived by ambulance and were in the oldest age group (65 and over), odds of admission remain significantly different between sites even when controlling for these variables. However, our accompanying qualitative analysis of organisational factors suggests that cultural factors may be important; respondents identified additional management pressures at site 2 and a less supportive environment for junior staff as important factors in explaining admission risk [22]. Deconstructing the "cultural" factors that may contribute to admission risk is an important area for future research. Analysis of demographic factors in this study corroborates results from analyses elsewhere, notably the clear relationship between rising deprivation level and admission risk fits with findings from a range of other studies [4, 5, 7, 8, 9], and the increased risk of admission observed for patients of black or black British ethnicity, a strong association possibly reflecting the particular burden of chronic disease morbidity in these patients.

These findings suggest that other ED-related and clinician level behaviours may play an important role in admission rates. In particular, the strength of the observed relationship between late discharge (i.e. patients who leave the ED in the 10 minutes preceding the four-hour target and risk of admission suggests that the four-hour waiting time target for EDs in England influence decisions to admit. Clinicians may be admitting patients they had expected to discharge, as they were unable to complete their diagnostic and/or therapeutic work up in the four-hour time frame. Conflicting findings from analysis using a variety of ED workload measures, some of which (e.g. LWBT intensity and

ED bed occupancy rate) are regarded as well-validated measures suggest that caution should be exercised in using quantitative proxies for workload. Nevertheless, results suggest that knowledge of high bed occupancy in the ED may dissuade clinical teams from admitting patients, although no relationship with inpatient bed occupancy was demonstrated.

Strengths and limitations of the analysis

This cross-sectional analysis of attendance data from three EDs in England is among the first to use routine ED data to develop a multi-dimensional view of patient-related, presentational and department workload factors that may influence admission decision-making. However, the use of routine ED data exposed significant problems with coding and definitions that have been discussed elsewhere [31], and the absence of patient diagnosis and co-morbidity data is a major limitation to this analysis. Both factors may have an important bearing on admission risk. However, the selection of three hospital sites serving similar parts of London where we would not expect to see systematic differences in the quality of primary care, and analysis of data on a large number of attendances (approaching 20,000) of varying acuities, suggests that patient case-mix is unlikely to fully account for the significant variation in admission risk observed between sites. On the other hand, this may limit the generalizability of findings since the selected sites are within relatively close geographic proximity to one another. Secondly, the use of presentation data covering a single winter month in which there is often significant volatility in emergency attendances is a limitation which might be addressed through inclusion of data covering longer time periods in future studies [32]. Thirdly, a subset of patients were identified as having presented on multiple occasions. For the purposes of this analysis, all attendances were treated as unique events and no supplementary analysis of repeat attenders with (potentially) linked attendance patterns was attempted. Finally, ED workload variables were generated for each patient at a single, fixed time-point and are therefore an approximation. This was particularly the case for inpatient bed occupancy rates, for which only daily bed occupancy rates for each site could be obtained. However, it also applies to measures such as consultant staffing, for which single estimates were generated based on the patient's time of arrival. This may have led to the analysis of some attendances as "consultant staffed", when in fact a consultant was not on duty when the decision to admit or discharge was made. The cross-sectional design of the study meant that it was not possible in this analysis to model ED workload factors as dynamic variables. Building a more complete picture of variations in risk over time is an important area for further research.

CONCLUSIONS

In this analysis, risk of inpatient admission was found to be significantly higher at two of the sites when compared with the first, adjusting for a variety of demographic, patient presentation and departmental factors. Risk of admission was also greater for those of black or black British ethnicity. Evidence on the role of ED workload factors was conflicting, but the four-hour target emerges as a strong driver for admission behaviour.

<DETAILS>

COMPETING INTERESTS: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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ETHICAL APPROVAL: this study was reviewed by the host Trust Research and Development Board. As there were no deviations from usual care, no interventions, no medications and data was both retrospective and was anonymised, no formal IRAS application was required. The study was registered in accordance with Trust guidelines and governance procedures.

GUARANTOR: TH

CONTRIBUTORSHIP: IP, DM and TH initiated the project, designed the study and specified the data collection protocol. IP, RC, EG, RL and GJ collected the data. SAI cleaned and transformed the data, incorporated new variables and performed the statistical analysis. SAI and IP drafted and revised the manuscript. DM, BB and TH commented on and revised the manuscript.

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DATA SHARING: The authors will provide upon request an anonymised version of the full data set if required.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	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
Introduction			
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
Methods			
Study design	4	Present key elements of study design early in the paper	4-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
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	5-6
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-7
		(*b*) Describe any methods used to examine subgroups and interactions	6-7
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

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	7-106
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-106 8
		(b) Indicate number of participants with missing data for each variable of interest	7-8
Outcome data	15*	Report numbers of outcome events or summary measures	107
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	12-139
		(*b*) Report category boundaries when continuous variables were categorized	5-76
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-150
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	150 11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-150 11
Generalisability	21	Discuss the generalisability (external validity) of the study results	150 11
Other information			
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	162

*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.