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Changes in weekend and weekday care quality of emergency medical admissions to 20 hospitals in England during implementation of the 7-day services national health policy

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ABSTRACT

Background In 2013, the English National Health Service launched the policy of 7-day services to improve care quality and outcomes for weekend emergency admissions.

Aims To determine whether the quality of care of emergency medical admissions is worse at weekends, and whether this has changed during implementation of 7-day services.

Methods Using data from 20 acute hospital Trusts in England, we performed randomly selected structured case record reviews of patients admitted to hospital as emergencies at weekends and on weekdays between financial years 2012–2013 and 2016–2017. Senior doctor ('specialist') involvement was determined from annual point prevalence surveys. The primary outcome was the rate of clinical errors. Secondary outcomes included error-related adverse event rates, global quality of care and four indicators of good practice.

Results Seventy-nine clinical reviewers reviewed 4000 admissions, 800 in duplicate. Errors, adverse events and care quality were not significantly different between weekend and weekday admissions, but all improved significantly between epochs, particularly errors most likely influenced by doctors (clinical assessment, diagnosis, treatment, prescribing and communication): error rate OR 0.78; 95% CI 0.70 to 0.87; adverse event OR 0.48, 95% CI 0.33 to 0.69; care quality OR 0.78, 95% CI 0.70 to 0.87; all adjusted for age, sex and ethnicity. Postadmission in-hospital care processes improved between epochs and were better for weekend admissions (vital signs with National Early Warning Score and timely specialist review). Preadmission processes in the community were suboptimal at weekends and deteriorated between epochs (fewer family doctor referrals, more patients with chronic disease or palliative care designation).

Conclusions and implications Hospital care quality of emergency medical admissions is not worse at weekends and has improved during implementation of the 7-day services policy. Causal pathways for the weekend effect may extend into the prehospital setting.

INTRODUCTION

In 2013, National Health Service England launched the 7-day services programme[1] '*designed to ensure patients that are admitted as an emergency, receive high quality consistent care, whatever day they enter hospital*'.[2] The programme consisted of 10 service delivery standards of which six involved increasing consultant involvement in frontline care. The stimulus for this policy derived in part from the perception that the higher mortality associated with weekend admission to hospital was attributable to the absence of senior medical staff at weekends.[3 4] This theory was first proposed by Bell and Redelmeier[5] in 2001, but in the accompanying editorial,[6] Halm and Chassin[6] observed that '*Disentangling the potential causal pathways would require painstaking detective work*'. Since then more than 600 studies of the weekend effect have been published; our group has recently undertaken a meta-ananlysis of 68 studies involving 640 million general unselected emergency and elective

weekend admissions to hospital, with a pooled excess relative risk of mortality of 16% for weekend admissions.[7] However, few studies have conducted the 'painstaking detective work' to elucidate the potential causal pathways.

Recent studies suggest multifactorial causes for the weekend effect. Weekend admissions are sicker,[8–11] and there is also a denominator contribution from fewer patients being admitted at weekends despite a similar emergency department (ED) attendance rate.[8 12] A cross-sectional analysis of hospitals in England[13] found a marked reduction in specialist (consultant) intensity at weekends but no relationship between specialist intensity and risk of death for weekend emergency admissions. Moreover, there does not appear to be a relationship between weekend admission mortality and the adoption of 7-day service standards.[14] In theory, reduced weekend staffing and resources should affect all hospitalised patients not just those newly admitted, but studies have shown a lower mortality rate among already-hospitalised patients at weekends compared with weekdays.[3 15]

None of these studies assessed hospital quality of care, the putative mediating variable for increased risk of death for weekend admissions. Previous studies of quality of healthcare have shown a tendency towards improvement over time[16 17] but did not examine weekend:weekday differences. More recently a study of stroke care across England has shown improvements in outcomes for weekend admissions over time, unrelated to centralisation of services.[18] We therefore examined error and associated adverse event rates among 4000 patients admitted as emergencies at weekends and on weekdays to 20 hospital Trusts in England during two epochs representing the preimplementation and postimplementation phases of the roll-out of 7-day services. We also attempt to explicate causal links by studying patient admission pathways and case mix, as part of the High-intensity Specialist Led Acute Care (HiSLAC) project[19] funded by the National Institute for Health Research, Health Services and Delivery Research (HS&DR) programme.

AIMS

To determine whether the quality of hospital care of patients admitted as medical emergencies is worse at weekends and whether care quality has changed between epochs during the implementation of 7-day services.

METHODS

We compared error rates, quality of care and patient admission pathways between weekend and weekday admissions in hospitals with higher and lower specialist intensities at weekends and between epochs. We recapitulate briefly here the methodology that has been described in detail previously.[20]

Selection of hospital Trusts

We invited 20 of the 115 acute hospital Trusts in England participating in the HiSLAC project[13] to take part. Trusts were classified first into quintiles of size (acute beds) and then four were selected from within each quintile, two with the highest and two with the lowest Sunday specialist intensity (2014 data) (online supplemental table 1). Data on specialist intensity (hours of consultant time per 10 emergency admissions) were derived from the HiSLAC national point prevalence survey conducted annually on a Sunday and a Wednesday in June between 2014 and 2018[20] (data on specialist intensity for the 5 years is in press, *Health Services and Delivery Research Journal* 2020). Following an on-site initiation visit, each Trust provided an anonymised and hash-encrypted Patient Administration System (PAS) dataset for all admissions during two epochs, financial year 1 April 2012–31 March 2013 and 1 April 2016–31 March 2017.

Case record review

We based our approach to obtaining case records on the method used for the evaluation of the Safer Patient Initiative.[21] We chose not to confine the study to mortality reviews in order to avoid endogenous selection bias (from the outcome influencing the sample) and to ensure that the study population was representative. We focused the study on non-operative emergency medical admissions, that is, patients who were not admitted for surgery, using a code to identify non-surgical procedures. Following submission and data cleaning, from each Trust's PAS datasets, we randomly selected 200 admissions, 100 from each epoch, each with 50 weekend and 50 weekday admissions, a total of 4000 unique admissions. Trusts were reimbursed £600 for staff to copy and scan the case records, masking patient identifiers (name, address, age and postcode); records were censored for lengths of stay exceeding 7 days. All available documents relating to the first 7 days of the admission were included: ambulance and ED records, physician and nursing entries, correspondence and reports of laboratory and radiological tests. Records of previous admissions or readmissions were not included, only the index admission. Radiological reports were included but not the images. Record completeness was assured using a checklist. Files were transferred using a file share program to a central repository at the University of Birmingham and checked for anonymisation. Complete records were uploaded to REDCap[22] and allocated randomly to the reviewers.

The 79 case record reviewers were consultants (attendings) and senior registrars (senior residents) in acute medical specialities. Reviewers attended one of three centralised half-day practical training sessions in case record reviewing (data identification, error typology, adverse events, care quality and bias). Reviewers accessed the password-protected

case records online independently in their own time. Progress was monitored every 2 weeks, with group reminders and personal contacts if required. An honorarium of £10 per completed review was paid at the end of the project.

Patient admission pathways and care processes

Reviewers identifed from the case records the patients' preadmission and postadmission pathways including how patients arrived at the hospital (referral from family doctor, emergency ambulance and self-presentation), vital signs documentation and calculation of the National Early Warning Score (NEWS), initial and subsequent location following admission, timeliness of specialist review and palliative care decisions. Case mix was derived from PAS data.

Assessment of errors, adverse events, preventability and global assessment of care quality

We employed structured judgement review[23–25] to identify and characterise errors and associated adverse events. This is the recommended approach for national mortality reviews in the UK, facilitating a degree of standardisation in decision making while still permitting individual judgement. Reviewers were not blinded to dates because of the requirement to determine timeliness of specialist reviews. Error typologies were based on those used by Hogan *et al*.[23] Reviewers then gave a free-text description of the error; more than one typology could be chosen per error. Error-related adverse events were graded for preventability using a six-point scale from 'virtually no evidence for preventabiity' to 'virtually certain evidence'.[26] Error-related adverse events (corresponding to 'preventable adverse events') distinguish adverse events preceded by an error from those attributable to the underlying disease(s). Reviewers gave each case a global assessment of care quality ('To what extent did this patient receive best practice care?') using a five-point scale from 'completely' to 'not at all'. The data collection fields are provided in the published protocol.[20]

Patient and public involvement (PPI)

Patients and the public have been involved in three ways. First, a PPI representative (PR) has been a full collaborator in the project from inception, contributing to metric development and interpretation of results. Second, a PPI representative (PS) has been a full and active member of the Oversight and Governance Committee. Third, patients and relatives contributed to the information gleaned by the ethnographers during their site visits to the 20 Trusts (data not presented here).

Statistical analysis

The primary outcome was the rate of clinical errors among emergency admissions. Secondary outcomes included: error-related adverse event rates, global quality of care assessments and four explicit indicators of good practice (appropriate initial treatment location, completeness of vital signs and NEWS reporting and timeliness of specialist review, ie, within 14 hours of admission).

For the main analysis, each of the 4000 case records was reviewed by one of 79 reviewers. In addition, 800 records (40 from each trust, of which 20 from each epoch) were selected for a second review by a randomly chosen reviewer to assess inter-reviewer reliability. Reviewer reliability coefficients were computed from these repeat reviews. Intraclass correlation coefficients (with class=case record) were used for errors and adverse events and a (linearly) weighted kappa coefficient for the 5-point quality of care Likert scale. The reliability of aggregated assessments (within Trusts and epochs) was estimated using the Spearman-Brown formula.[27]

The outcomes were analysed using mixed effects generalised linear models. Negative binomial models were used for numbers of errors, logistic models for adverse events and process indicators and an ordinal logistic model for the quality of care Likert scale. In all models, fixed effects were fitted for hospital Trust, day of week (weekend/weekday) and time-epoch; random effects were fitted for reviewers. All models were adjusted for patient age (using restricted cubic splines with five knots), sex and ethnicity (Caucasian, non-Caucasian and missing). Changes in the weekend effects over time were captured by adding day by epoch interaction terms to the mixed effects models. Trust-level effects were extracted for correlation analysis with estimates of specialist involvement (specialist hours per 10 emergency admissions) from the point prevalence survey. Peason's χ^2 test was used to compare the difference between epochs, weekend versus weekday, for the preadmission data.

Ethics

Informed consent was not required for accessing anonymised patient records.

RESULTS

Demographics

Four thousand case records were retrieved. The characteristics of the randomly selected study population were representative of the hospital admitted population in England (online supplemental table 2). Median length of hospital stay was 2 days.

Case records and reviews

Seventy-nine reviewers participated; the mean number of reviews per reviewer was 61 (20–69), with 800 records reviewed in duplicate. Reviewers felt unable to provide an assessment of errors and global assessment of care quality in 28 (insufficient documentation), of error alone in 6 and of quality alone in 5. Of the 1600 duplicate reviews, 1584 could be used

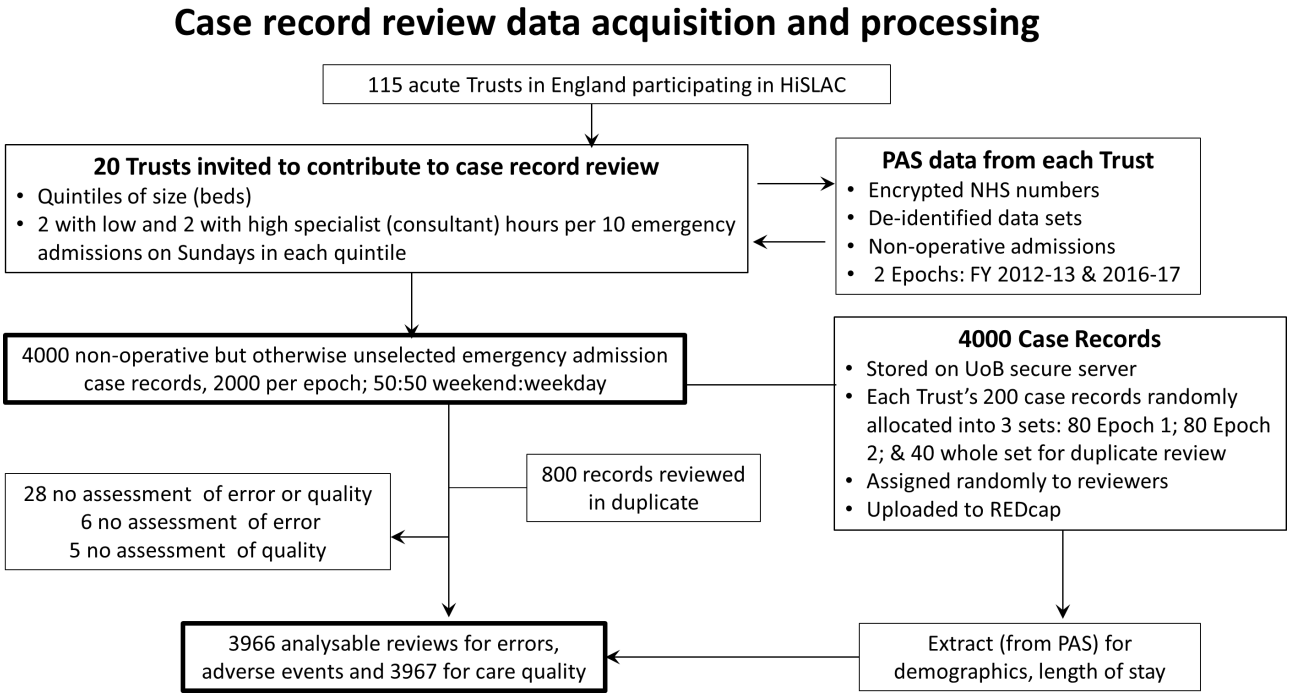

Figure 1 Case record review data acquisition and processing. HiSLAC, High-intensity Specialist Led Acute Care; NHS, National Health Service; PAS, Patient Administration System; UoB, University of Birmingham.

for inter-reviewer reliability of assessment of error and 1586 for care quality (figure 1).

Admission pathways

Data extracted by the reviewers on the preadmission pathway are summarised in online supplemental table 3a and the postadmission pathway in online supplemental table 3b.

Preadmission pathways (online supplemental table 3a): the majority of patients were admitted from home. Weekend admissions were more likely to be dependent on others for activities of daily living (weekend 11.0% vs weekday 8.3%, p=0.0038) and to reach hospital by emergency ambulance (51.6% vs 42.1%, p<0.0001), less likely to have been referred by a general practitioner (8.2% vs 19.8%, p<0.0001) and less likely to be admitted directly to an acute ward bypassing the ED (8.0% vs 14.6%, p<0.0001). These weekend–weekday differences were more marked for the second epoch than the first. Weekend admissions were more likely to include patients in whom a palliative care decision was already in place, or was applied at the time of admission, or in the opinion of the reviewer should have been made (17.1% vs 14.1%, p=0.0089), with a marked increase between epochs (13.2% vs 18.1%, p<0.0001). Fewer weekend than weekday admissions were considered definitely or possibly avoidable by the reviewers (24.3% vs 28.4%, p=0.0032).

Postadmission errors, error-related adverse events, global quality of care and care processes

Errors: of the 4000 case records (equally divided between weekend and weekday admission), 3966 could be assessed for errors and 3967 for care quality. One or more errors in care were identified in 996 records: 1618 errors were identified in total. Single errors were identified for 16.1% of reviews and two or more for 8.8% (table 1). The most frequent category of error was 'clinical assessment, investigation or diagnosis' (31.9%) followed by 'treatment and management' (29.1%), 'communication' (15.3%) and 'medication' (13.2%) (online supplemental table 4).

Adverse events: reviewers identified 128 adverse events in 103 patients (2.6%). Ninety-one adverse events were judged to have a >50% chance of being preventable (online supplemental table 4).

Global quality assessment: reviewers considered that best practice care had been provided completely in 1579 (39.5%) of cases, substantially in 1659 (41.5%), partially in 623 (15. 6%), very little in 83 (2.1%) and not at all in 23 (0.8%) (online supplemental table 4).

Care processes (tables 1 and 2 and online supplemental table 3b): the initial location for admission (usually the acute medical unit) was considered appropriate for most admissions regardless of the day of admission. Vital signs were incomplete for 32.0% of admissions, calculation of NEWS was absent in 51.5% and specialist review within 14 hours was not formally documented in 70.3%.

Weekend:weekday admission differences

Of the 1618 identified errors, 803 were in weekend admissions and 815 in weekday admissions (table 1). The overall error rate per case was similar for weekend (0.405) and weekday (0.411) admissions (adjusted rate ratio 0.96; 95% CI 0.86 to 1.07; p=0.4922) (table 2,

Table 1 Number of errors, error-related adverse events and process indicators, by weekend–weekday admission and epoch

	Both epochs			Epoch 1			Epoch 2		
	Total	W/E	W/D	Total	W/E	W/D	Total	W/E	W/D
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Total	**4000**	**2000**	**2000**	**2000**	**1000**	**1000**	**2000**	**1000**	**1000**
Total number of errors	1618	803	815	914	440	474	704	363	341
Number of errors									
None	2970 (74.3)	1486 (74.3)	1484 (74.2)	1447 (72.4)	723 (72.3)	724 (72.4)	1523 (76.2)	763 (76.3)	760 (76.0)
Any error	996 (24.9)	497 (24.9)	499 (25.0)	541 (27.1)	269 (26.9)	272 (27.2)	455 (22.8)	228 (22.8)	227 (22.7)
1	645 (16.1)	328 (16.4)	317 (15.9)	338 (16.9)	178 (17.8)	160(16)	307 (15.4)	150 (15.0)	157 (15.7)
2	208 (5.2)	100 (5.0)	108 (5.4)	121 (6.1)	53 (5.3)	68 (6.8)	87 (4.4)	47 (4.7)	40 (4.0)
3	83 (2.1)	36 (1.8)	47 (2.4)	43 (2.2)	18 (1.8)	25 (2.5)	40 (2.0)	18 (1.8)	22 (2.2)
4	31 (0.8)	17 (0.9)	14 (0.7)	22 (1.1)	12 (1.2)	10 (1.0)	9 (0.5)	5 (0.5)	4 (0.4)
5 or more	29 (0.7)	16 (0.8)	13 (0.7)	17 (0.9)	8 (0.8)	9 (0.9)	12 (0.6)	8 (0.8)	4 (0.4)
Missing	34 (0.9)	17 (0.9)	17 (0.9)	12 (0.6)	8 (0.8)	4 (0.4)	22 (1.1)	9 (0.9)	13 (1.3)
Mean number of errors per patient admission*	0.408	0.405	0.411	0.460	0.444	0.476	0.356	0.366	0.345
Patients with one or more adverse events	103	49	54	68	31	37	35	18	17
Process indicators									
Location not appropriate	118 (3.0)	59 (3.0)	59 (3.0)	61 (3.1)	29 (2.9)	32 (3.2)	57 (2.9)	30 (3.0)	27 (2.7)
Incomplete vital signs	1280 (32.0)	596 (29.8)	684 (34.2)	597 (29.9)	280 (28.0)	317 (31.7)	683 (34.2)	316 (31.6)	367 (36.7)
NEWS not recorded	2060 (51.5)	982 (49.1)	1078 (53.9)	1090 (54.5)	521 (52.1)	569 (56.9)	970 (48.5)	461 (46.1)	509 (50.9)
No specialist review <14 hours documented	2811 (70.3)	1393 (69.7)	1418 (70.9)	1448 (72.4)	727 (72.7)	721 (72.1)	1363 (68.2)	666 (66.6)	697 (69.7)

*Calculated using 'total number of errors ÷ (all records excluding errors missing)'.
NEWS, National Early Warning Score; W/D, weekday; W/E, weekend.

Table 2 Analysis of error rates, adverse events, quality of care and process indicators between epochs, between day of admission and between day of admission between epochs

	Epochs (epoch2:epoch1)		Day of admission (weekend:weekday)		Weekend:weekday Between epochs	
	RR (OR)* (confidence limits)	P value	RR (OR)* (confidence limits)	P value	RR (OR)* (confidence limits)	P value
Errors						
Assessment, investigation or diagnosis	0.71 (0.61 to 0.83)		0.93 (0.79 to 1.10)		1.14 (0.77 to 1.69)	
Treatment and management	0.74 (0.63 to 0.87)		0.97 (0.83 to 1.13)		1.18 (0.80 to 1.73)	
Communication	0.84 (0.66 to 1.07)		1.08 (0.87 to 1.34)		1.44 (0.93 to 2.23)	
Medication	0.65 (0.52 to 0.81)		0.92 (0.72 to 1.19)		0.86 (0.50 to 1.47)	
Monitoring	0.78 (0.55 to 1.11)		0.94 (0.70 to 1.27)		0.89 (0.36 to 2.21)	
Resuscitation	0.82 (0.37 to 1.81)		2.61 (1.15 to 5.91)		1.14 (0.16 to 8.03)	
Infection	2.35 (0.71 to 7.76)		0.73 (0.24 to 2.26)		1.23 (0.13 to 11.5)	
Invasive procedures	0.46 (0.20 to 1.04)		1.63 (0.70 to 3.77)		1.15 (0.21 to 6.27)	
Other	0.52 (0.30 to 0.92)		1.21 (0.78 to 1.86)		1.20 (0.44 to 3.29)	
All errors	0.78 (0.70 to 0.87)	<0.0001	0.96 (0.86 to 1.07)	0.4922	1.14 (0.91 to 1.45)	0.2566
Adverse events	0.48 (0.33 to 0.69)	0.0001	0.89 (0.57 to 1.38)	0.5991	1.29 (0.54 to 3.08)	0.5663
Global quality of care	0.78 (0.70 to 0.87)	<0.0001	0.98 (0.86 to 1.10)	0.6904	1.03 (0.81 to 1.31)	0.7973
Process indicators						
Location not appropriate	0.91 (0.64 to 1.30)	0.6170	1.00 (0.71 to 1.42)	0.9961	1.16 (0.54 to 2.46)	0.7051
Incomplete vital signs	1.25 (1.07 to 1.47)	0.0056	0.80 (0.71 to 0.91)	0.0009	0.99 (0.74 to 1.32)	0.9267
NEWS not recorded	0.75 (0.65 to 0.88)	0.0003	0.81 (0.71 to 0.93)	0.0026	1.06 (0.79 to 1.43)	0.6805
Specialist review <14 hours not documented	0.82 (0.72 to 0.93)	0.0026	0.95 (0.81 to 1.11)	0.5142	0.86 (0.68 to 1.09)	0.2194

Adjusted for age, sex, ethnicity and hospital trust.
*Rate ratios for errors (from mixed effects negative binomial models); ORs for adverse events and process indicators (from mixed effects binary logistic models); proportional ORs for global quality of care (from mixed effects ordinal logistic regression).
OR, odds ratio; RR, rate ratio.

middle column). Similarly, there was little difference in adverse event rates or global care quality between weekend and weekday admissions. Documentation of vital signs and calculation of a NEWS were more complete for weekend admissions (50.9% vs 46.1%) (online supplemental table 3b), with consequential improvements in two of the process indicators (adjusted ORs 0.80; 95% CI 0.71 to 0.91 and 0.81; 95% CI 0.71 to 93). Initial specialist review within the first 14 hours following admission (combining 'documented' with 'probable' specialist reviews) indicated that this had occurred in 1189 (29.7%) of cases overall, 30.4% for weekend admissions and 29.1% for weekday (online supplemental file 1).

Temporal trends between epochs (2012–2013 and 2016–2017)

In contrast to weekend:weekday admission comparisons, the overall error rate between epochs reduced significantly (adjusted rate ratio 0.78; 95% CI 0.70 to 0.87; p<0.0001), and this was reflected to some extent in every error category save that of 'Infection' (table 2). A significant reduction was also observed between epochs in error-related adverse events; 103 patients suffered 128 adverse events, 68 in epoch 1 and 35 in epoch 2 (adjusted OR 0.48, 95% CI 0.33 to 0.69, p=0.0001) (tables 1 and 2). There was some improvement in care quality (adjusted OR 0.78, 95% CI 0.70 to 0.87, p=0.0001, table 2): for instance, the proportion of reviews attracting the two highest care quality assessments ('completely' and 'substantially') rose from 79.4% in Epoch 1 to 82.5% in Epoch 2 (online supplemental table 4). There was no evidence for temporal change in weekend:weekday differences over time for any outcome measure (table 2, final column).

The indicators for calculation of NEWS (adjusted OR 0.75; 95% CI 0.65 to 0.85) and timely consultant review (adjusted OR 0.82; 95% CI 0.72 to 0.92) improved over time. Indeed, the documentation of vital signs and calculation of the NEWS changed from 47.9% to 53.9% at weekends and from 43.1% to 49.1% on weekdays (online supplemental table 3b). However, the proportion of cases in which vital signs were absent or incomplete increased between epochs (adjusted OR 1.25; 95% CI 1.07 to 1.47). Specialist review within 14 hours of admission was documented in the case record in 22.6% (weekend) and 24.8% (weekday) of case reviews for epoch 1, increasing in epoch 2 more markedly for weekend than weekday admissions (30.3% vs 27.2%, respectively). Combining 'documented' with 'probable' specialist review within

Table 3 Inter-reviewer reliability

Error category and global quality	All reviews (n=4763)	Errors per review			Repeat reviews (n=1584 = 2 × 792 reviews in total)		
	Errors	Mean	SD	Max.	Errors	Individual-level reliability*	Trust-level reliability†
Assessment	903	0.19	0.58	12	272	0.003	0.138
Treatment	824	0.17	0.54	10	265	0.131	0.883
Communication	442	0.09	0.44	14	140	0.058	0.753
Medication	380	0.08	0.34	8	129	0.072	0.794
Monitoring	138	0.03	0.19	4	47		
Resuscitation	38	0.01	0.10	2	12		
Infection	26	0.01	0.08	2	11		
Invasive	25	0.01	0.08	2	5		
Other	75	0.02	0.13	2	25		
All errors	1909	0.40	0.92	15	606	0.026	0.568
Global QoC						0.105	0.854

*Omitting categories with fewer than 50 errors reported among the repeat reviews.
†Computed from the Spearman-Brown formula with 50 case notes per trust.
QoC, Quality of Care.

14 hours showed no difference between weekends and weekdays but an improvement between epochs (weekends 27.3%–33.4%; weekdays 27.9%–30.3%).

Inter-reviewer differences

There was substantial variation between reviewers in error identification rates (online supplemental figure 1). Repeat reviewer assessments were available for 792 case records for error and 793 for global quality. Reviewer reliability coefficients were generally low (table 3). However, the study does not aim to establish the quality of care for any particular patient but is concerned with aggregate data within individual Trusts; that is, the 50 case notes representing each Trust in a particular epoch for weekend or weekday admissions. The reliability of such aggregates estimated using the Spearman-Brown formula is much higher, as shown in table 3.

Trust-level aggregate measures

Error and global quality: the relationship between error rates and global care quality at Trust level is represented in figure 2. Estimates of the Trust level (for 'All Errors' and 'Global Quality' of care) obtained from the models reported in table 2 are plotted against one another. The estimates came with (average) SEs of 0.15 from the error model and 0.16 from the quality of care model. Since the SD of the actual estimates was 0.28 for both errors and quality of care, this means that about 70% ($\approx 1 - (0.15/0.28)^2$) of the variation in the figure is due to genuine differences between trusts. Nevertheless, the overall correlation is not convincing (r=0.168, p=0.478); indeed, Trusts 10 and 15 recorded the lowest error rates but were among the bottom three for care quality assessments.

The weekend effect and specialist intensity

As we found no relationship between errors and day of admission, but a clear reduction in error rates between epochs, we undertook exploratory analyses related to specialist intensity. Specialist intensity was both a criterion for selecting the 20 Trusts (10 low and 10 higher weekend intensity) and a secondary outcome measure in terms of change over time. We therefore tried to determine if the secular change was associated with an overall improvement in specialist intensity—the rising tide phenomenon.

The specialist intensity point prevalence surveys were conducted over a 5-year period (2013/2014–2017/2018), which spanned the epochs of the case note review. Specialist intensity was defined as the number of dedicated specialist hours per 10 emergency admissions. The data were used to estimate the weekend:weekday intensity ratio for each trust.

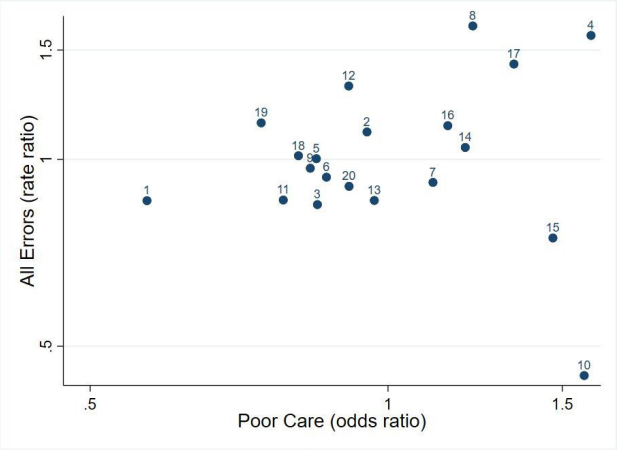

Figure 2 Error and global care quality. Rate-ratio for the presence of all errors and the OR for (worse) quality of case are plotted on a logarithmic scale, with a value of 1 corresponding to the average trust.

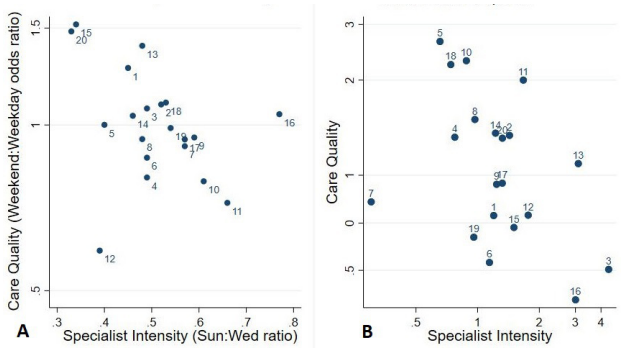

Figure 3 Trust-level weekend effects for quality of care and specialist intensity: (A) pooled over both epochs and all PPS time points. (B) Relative changes between two epochs. (A) a value above 1 indicates that the gap between weekend and weekday care is worse than average. (B) a value below 1 indicates that the gap between weekend and weekday care has improved over time. PPS, Point Prevalence Survey.

The average over the 20 trusts of the intensity ratio obtained from the 5 years of survey data was 0.51 (SD 0.11) reflecting a much lower specialist attendance at weekends. The 7-day initiative is predicated on the assumption that the equalisation of hospital services across the week would lead to an improvement in the quality of weekend care relative to weekdays. This might mean: (A) that Trusts with relatively higher weekend:weekday intensity ratios tend to deliver more equal standards of care across the week and/or (B) that Trusts where the intensity ratio has increased between the two epochs will show a corresponding improvement in weekend care relative to weekdays. These possibilities are examined in figure 3A,B.

In figure 3A, Trust-level weekend effects for quality of care (ie, weekend:weekday ratios pooled over both epochs) are plotted against the corresponding 5-year intensity ratios. The correlation is negative, as expected, indicating that Trusts with a larger weekend:weekday difference in specialist staffing also have a larger difference in care quality, but the correlation is not formally significant ($r=-0.433$, $p=0.057$).

In figure 3B, we examine changes over time. The intensity ratios from 2013 to 14 (mean 0.47, SD 0.18) were taken as representative of epoch 1, and those from 2016 to 17 (mean 0.58, SD 0.27) as representative of epoch 2. In this way, a ratio of weekend effects between epochs can be calculated for each Trust, both for global quality of care and for specialist intensity. The resulting plot yields an almost identical correlation to figure 3A ($r=-0.428$, $p=0.060$), consistent with the interpretation that the gaps between weekend and weekday care quality and specialist intensity have both tended to narrow over time.

A similar analysis using Trust-level weekend effects for the presence of error in place of poor care quality (figure not shown) produced a somewhat smaller negative correlation ($r=-0.34$, $p=0.149$).

DISCUSSION

The national 7-day services policy[1] was intended to improve quality of care for patients admitted to hospital as emergencies at weekends by requiring hospital Trusts to increase specialist (consultant) input and services to a level similar to that of weekdays. However, there was little evidence that care quality in hospital was actually worse at weekends or that increasing specialist intensity would improve outcomes. In this two-epoch study of 4000 case records across 20 Trusts, we find no support for the concept that the quality of in-hospital medical care of patients undergoing emergency admission is lower for patients admitted at weekends compared with weekdays. If there is a signal, it would suggest some slight advantage for weekend admissions. However, our study provides strong evidence of a temporal trend towards improved hospital care between epochs: there was a statistically significant improvement in error rates, error-related adverse events and global quality of care assessments. These findings triangulate well with improvements in in-hospital processes of care between epochs (initial specialist review; recording NEWS). They are also aligned with the 'rising tide' phenomenon[28] of secular improvements in care processes reported previously.[16] The error-related adverse event rate of 2.6% in our set of relatively short-stay admissions is consistent with a recent systematic review reporting a median prevalence of 5% (IQR 3%–9%) for preventable adverse events across 70 studies between 2000 and 2018.[29]

The 7-day services initiative[1] may have contributed to the reduction in error rates between epochs, particularly those most influenced by doctors—assessment, diagnosis, treatment, prescribing and communication—by promoting timely specialist reviews across all days of the week. There may be a moderate relationship between specialist intensity and judgements of care quality (figure 3A), and a trend for Trusts, which narrow the Sunday:Wednesday specialist intensity gap between epochs 1 and 2 also to reduce the weekend:weekday global care quality gap between epochs (figure 3B), though neither achieves conventional statistical significance (alpha 5%) at this sample size. Other factors that might have contributed to improved care over time include increased input from allied health professionals,[30] or the introduction of electronic prescribing and patient records, though benefits of digitisation compared with paper records remain uncertain.[31–33] It is possible that the reduction in raw vital signs recording between epochs with a concurrent increase in complete vital signs with NEWS calculation could represent a transition to electronic recording and automated NEWS calculation.

It should also be noted that the absence of a weekend effect for care quality in hospital does not mean that care quality overall is satisfactory: there is scope for improvement in documenting vital signs and in timely

specialist review across all days of the week. Even in the second epoch, a consultant review was documented in only half the case records and within 14 hours of admission in only one-third. Further work is needed to determine whether the absence of consultant review is associated with a decrement in care quality.

The prehospital data were included as part of the demographic descriptors and are presented here for hypothesis generation. Prehospital processes appear to contrast markedly with the in-hospital postadmission data. Patients admitted at weekends were more likely to be physically dependent, to have a palliative care decision in place and to have arrived by ambulance into the ED and much less likely to have been referred by a general practitioner in the community. All these indicators were more marked in the second epoch than the first. These findings are consistent with other studies showing that weekend admissions from the community are sicker than those admitted on weekdays[8 9] and that there are fewer GP referrals at weekends.[8 12] As these changes have occurred at the same time as a reduction in social care funding despite increasing demand,[34] these findings suggest the possibility that at weekends there is a decrement in community care of vulnerable patients and that this has deteriorated with time.

Limitations and mitigation

Case record review is the most common method used in population-based assessments of adverse events and hospital quality of care but lacks precision when using a single review of a single record by an expert reviewer.[35] Joint reviews using consensus to resolve disagreements result in only an illusory improvement in reliability.[36] However, improvements in reliability can be achieved by averaging across multiple reviews.[37] Our sample of 200 case record reviews per Trust, 2000 per epoch, 4000 case records in total and 4763 usable reviews is one of the largest reviews undertaken and produces adequate reliability (0.8–0.9) for distinguishing between Trusts. By examining the 'difference-in-difference' (comparisons of ratios), we have minimised confounding that would occur from comparisons between different Trusts, for example, from variation in case mix. We have previously shown that patients admitted as emergencies at weekends tend to be more severely ill than those admitted on weekdays.[8] As severely ill patients may be more susceptible to healthcare error[38] (mainly because the opportunity for error is greater in these patients),[39] it might have been expected that error rates would be higher at weekends, but this is not the case.

CONCLUSION

In summary, we find no evidence that in-hospital care is worse for patients admitted at weekends. We find improvements in hospital care between 2012–2013 and 2016–2017, manifest by a reduction in error rates and adverse events, better care processes and higher global quality ratings by the reviewers. It is possible that 7-day services has contributed to these improvements. Indications that community care performs less well at weekends, and has deteriorated between epochs, suggest that the causal pathways for the weekend effect extend into the prehospital setting. Policy makers should focus their efforts to improve acute and emergency care on a 'whole system' integrated approach, which focuses on all days of the week and includes care in the community.

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Contributors JB: developed the original design and contributed to methodology development, analysis of data and writing manuscript. CA: data collection, methodology development, analysis of data and contribution to writing manuscript. AJG, GR and JS: data collection, methodology development, analysis of HES data, statistical analysis and contribution to writing manuscript. CT devised and led on the qualitative research design, analysis and writing of the manuscript; ES was involved in the design and together with JW contributed to organising and facilitating the focus groups and interviews, analysis and writing of the manuscript. RL: writing of the application, design of the project, health economics analysis and contribution to writing of manuscript. SIW developed the statistical methodology for the cost-benefit analysis and together with JL conducted health economics analysis and contributed to writing of the manuscript. CB: methodology development, development of case record review and reviewer training materials and contribution to writing manuscript. AB: data collection, methodology development and contribution to writing manuscript. Y-FC: systematic review, methodology development and contribution to writing manuscript. MC, TH, RM, PR, CR and MT: methodology development and contribution to writing manuscript. LR: collaborator engagement, dissemination of findings and contribution to writing manuscript.

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APPENDIX 2 - ELECTRONIC SUPLEMENTARY MATERIAL (ESM)

ESM Table 1: Status of 20 participating Trusts in 2014

Trust	Size (number of beds, range)	Quintile (based on number of beds)	Specialist hours per 10 Emergency Admissions*
1	986-2037	**5**	40.2
2			34.1
3			15.5
4			10.7
5	787-984	**4**	38.9
6			36.1
7			18.5
8			15.4
9	636-783	**3**	50.7
10			35.7
11			11.4
12			8.1
13	479-627	**2**	47.0
14			38.0
15			9.6
16			7.0
17	240-470	**1**	38.6
18			34.7
19			11.1
20			8.8

*Adjusted using the formulae N x (1 / Response Rate) and rounded to the nearest integer

ESM Table 2: Characteristics of study population versus background population

	Case Notes Review data						All trusts/hositals data*					
	Total		W/E		W/D		Total		W/E		W/D	
	n	%	n	%	n	%	n	%	n	%	n	%
Total	4000		2000		2000		5818430		1411394		4407036	
Age												
Mean (SD)	61.1	22.310	61.7	22.379	60.5	22.271	61	22.350	61	22.780	61	22.190
Median (IQR)	65	43-81	66	44-81	64	42-80	65	43-80	66	43-81	65	43-80
Gender												
Male	1869	46.7	938	46.9	931	46.6	2639489	45.4	645166	45.7	1994323	45.3
Female	2131	53.3	1062	53.1	1069	53.5	3178941	54.6	766228	54.3	2412713	54.7
Ethnicity												
Caucasian	3140	78.5	1584	79.2	1556	77.8	4918775	84.5	1191464	84.4	3727311	84.6
Non_Caucasian	818	20.5	396	19.8	422	21.1	526384	9.0	128736	9.1	397648	9.0
Unknown	42	1.1	20	1.0	22	1.1	373271	6.4	91194	6.5	282077	6.4
Top 5 primary discharge diagnosis (SHMI grouping)												
Nonspecific chest pain	227	5.7	116	5.8	111	5.6	326876	5.6	72314	5.1	254562	5.8
Pneumonia (excluding TB/STD)	186	4.7	105	5.3	81	4.1	322014	5.5	85643	6.1	236371	5.4
Urinary tract infections	176	4.4	100	5.0	76	3.8	235612	4.0	64076	4.5	171536	3.9
Abdominal pain	156	3.9	70	3.5	86	4.3	243013	4.2	54697	3.9	188316	4.3
COPD & bronchiectasis	128	3.2	67	3.4	61	3.1	193168	3.3	48288	3.4	144880	3.3
Other	3127	78.2	1542	77.1	1585	79.3	4497747	77.3	1086376	77.0	3411371	77.4
Length of stay												
median (IQR)	2	0-5	2	0-5	1	0-4	1	0-5	2	0-5	1	0-5
Zero length of stay												
ZLOS	1107	27.7	512	25.6	595	29.8	1739129	29.9	388274	27.5	1350757	30.7
Not-ZLOS	2871	71.8	1477	73.9	1394	69.7	4078719	70.1	1023261	72.5	3054076	69.3
Unknown	22	0.6	11	0.6	11	0.6	0	0.0	0	0.0	0	0.0
In-hospital mortality												
Died	168	4.2	90	4.5	78	3.9	239719	4.1	63372	4.5	176281	4.0

*from Hospital Episode Statistics (HES), of those trusts participating in HiSLAC speciality intensity prevalence survey from 2014 to 2018 financial years

ESM Table 3a: Reviewers' assessment on pre-admission patient pathways

	BOTH EPOCHS						EPOCH 1						EPOCH 2					
	Total		W/E		W/D		Total		W/E		W/D		Total		W/E		W/D	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total	**4000**		**2000**		**2000**		**2000**		**1000**		**1000**		**2000**		**1000**		**1000**	
Source of admission																		
Own home	3389	84.7	1711	85.6	1678	83.9	1712	85.6	865	86.5	847	84.7	1677	83.9	846	84.6	831	83.1
Nursing or residential care home	257	6.4	121	6.1	136	6.8	127	6.4	60	6.0	67	6.7	130	6.5	61	6.1	69	6.9
No information available	247	6.2	114	5.7	133	6.7	105	5.3	46	4.6	59	5.9	142	7.1	68	6.8	74	7.4
Another hospital	30	0.8	16	0.8	14	0.7	12	0.6	6	0.6	6	0.6	18	0.9	10	1.0	8	0.8
No fixed abode	70	1.8	34	1.7	36	1.8	41	2.1	21	2.1	20	2.0	29	1.5	13	1.3	16	1.6
Missing	7	0.2	4	0.2	3	0.2	3	0.2	2	0.2	1	0.1	4	0.2	2	0.2	2	0.2
Patient condition before admission																		
Independent	2611	65.3	1292	64.6	1319	66.0	1333	66.7	667	66.7	666	66.6	1278	63.9	625	62.5	653	65.3
Needing help with some activities of daily living (ADLs)	672	16.8	332	16.6	340	17.0	351	17.6	169	16.9	182	18.2	321	16.1	163	16.3	158	15.8
Dependant on others for most/all ADLs including personal hygiene	384	9.6	219	11.0	165	8.3	174	8.7	100	10.0	74	7.4	210	10.5	119	11.9	91	9.1
Unable to determine; no relevant information in notes	325	8.1	152	7.6	173	8.7	139	7.0	62	6.2	77	7.7	186	9.3	90	9.0	96	9.6
Missing	8	0.2	5	0.3	3	0.2	3	0.2	2	0.2	1	0.1	5	0.3	3	0.3	2	0.2
Referral to hospital mechanism																		
999/ambulance transfer to ED	1873	46.8	1032	51.6	841	42.1	995	49.8	550	55.0	445	44.5	878	43.9	482	48.2	396	39.6
Self-presentation to ED (walk-in/own transport)	847	21.2	455	22.8	392	19.6	402	20.1	215	21.5	187	18.7	445	22.3	240	24.0	205	20.5
GP or deputising service referral (documented letter or phone call)	559	14.0	164	8.2	395	19.8	288	14.4	88	8.8	200	20.0	271	13.6	76	7.6	195	19.5
Unable to determine	553	13.8	282	14.1	271	13.6	236	11.8	123	12.3	113	11.3	317	15.9	159	15.9	158	15.8
Patient instructed by GP to attend ED, no formal evidence of referral	93	2.3	29	1.5	64	3.2	51	2.6	16	1.6	35	3.5	42	2.1	13	1.3	29	2.9
Urgent Care Centre or Walk-In Centre referral	45	1.1	26	1.3	19	1.0	16	0.8	4	0.4	12	1.2	29	1.5	22	2.2	7	0.7
Self-presentation, patient instructed to attend by 111 service	20	0.5	7	0.4	13	0.7	7	0.4	2	0.2	5	0.5	13	0.7	5	0.5	8	0.8
Missing	10	0.3	5	0.3	5	0.3	5	0.3	2	0.2	3	0.3	5	0.3	3	0.3	2	0.2
Admission pathway																		
ED / pre-admission area	3354	83.9	1757	87.9	1597	79.9	1664	83.2	870	87.0	794	79.4	1690	84.5	887	88.7	803	80.3
Direct admission to acute ward	451	11.3	160	8.0	291	14.6	247	12.4	93	9.3	154	15.4	204	10.2	67	6.7	137	13.7
Unable to determine	187	4.7	78	3.9	109	5.5	86	4.3	35	3.5	51	5.1	101	5.1	43	4.3	58	5.8
(blank)	8	0.2	5	0.3	3	0.2	3	0.2	2	0.2	1	0.1	5	0.3	3	0.3	2	0.2
Pre_admission Vital Signs																		
Full set + NEWS calculated	1765	44.1	914	45.7	851	42.6	761	38.1	395	39.5	366	36.6	1004	50.2	519	51.9	485	48.5
Full set, no NEWS calculated	1282	32.1	656	32.8	626	31.3	781	39.1	391	39.1	390	39.0	501	25.1	265	26.5	236	23.6
Incomplete vital signs	322	8.1	160	8.0	162	8.1	187	9.4	91	9.1	96	9.6	135	6.8	69	6.9	66	6.6
No vital signs documented	365	9.1	180	9.0	185	9.3	133	6.7	71	7.1	62	6.2	232	11.6	109	10.9	123	12.3
Not applicable: patient not admitted via ED: direct admission to ward	253	6.3	81	4.1	172	8.6	133	6.7	48	4.8	85	8.5	120	6.0	33	3.3	87	8.7
Missing	13	0.3	9	0.5	4	0.2	5	0.3	4	0.4	1	0.1	8	0.4	5	0.5	3	0.3

ESM Table 3b: Reviewers' assessments of post-admission pathways & care processes

	BOTH EPOCHS						EPOCH 1						EPOCH 2					
	Total		W/E		W/D		Total		W/E		W/D		Total		W/E		W/D	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total	**4000**		**2000**		**2000**		**2000**		**1000**		**1000**		**2000**		**1000**		**1000**	
1st location post admission																		
Acute Medical Unit (AMU/MAU)	1401	35.0	690	34.5	711	35.6	704	35.2	327	32.7	377	37.7	697	34.9	363	36.3	334	33.4
Unable to determine ward type	655	16.4	319	16.0	336	16.8	317	15.9	164	16.4	153	15.3	338	16.9	155	15.5	183	18.3
Clinical Decision Unit or short stay ward	659	16.5	356	17.8	303	15.2	353	17.7	187	18.7	166	16.6	306	15.3	169	16.9	137	13.7
Other (please specify):	422	10.6	196	9.8	226	11.3	200	10.0	103	10.3	97	9.7	222	11.1	93	9.3	129	12.9
General Surgery (including surgical assessment/operating theatre)	376	9.4	193	9.7	183	9.2	179	9.0	99	9.9	80	8.0	197	9.9	94	9.4	103	10.3
Medical sub-specialities including high care (eg: Coronary Care Unit, Renal Unit, Respiratory, Haematology, Oncology)	215	5.4	103	5.2	112	5.6	116	5.8	47	4.7	69	6.9	99	5.0	56	5.6	43	4.3
General medical ward	171	4.3	84	4.2	87	4.4	88	4.4	47	4.7	41	4.1	83	4.2	37	3.7	46	4.6
Older Peoples Medicine/Elderly Care Unit	46	1.2	27	1.4	19	1.0	19	1.0	11	1.1	8	0.8	27	1.4	16	1.6	11	1.1
Critical Care Unit / Intensive Care Unit (including High Dependency)	33	0.8	20	1.0	13	0.7	18	0.9	11	1.1	7	0.7	15	0.8	9	0.9	6	0.6
Missing	18	0.5	10	0.5	8	0.4	5	0.3	3	0.3	2	0.2	13	0.7	7	0.7	6	0.6
Rehabilitation	4	0.1	2	0.1	2	0.1	1	0.1	1	0.1	0	0.0	3	0.2	1	0.1	2	0.2
Location appropriateness																		
Yes, definitely appropriate	2469	61.7	1215	60.8	1254	62.7	1234	61.7	602	60.2	632	63.2	1235	61.8	613	61.3	622	62.2
Probably appropriate	854	21.4	443	22.2	411	20.6	455	22.8	235	23.5	220	22.0	399	20.0	208	20.8	191	19.1
Unable to determine	534	13.4	270	13.5	264	13.2	240	12.0	128	12.8	112	11.2	294	14.7	142	14.2	152	15.2
No	118	3.0	59	3.0	59	3.0	61	3.1	29	2.9	32	3.2	57	2.9	30	3.0	27	2.7
Missing	25	0.6	13	0.7	12	0.6	10	0.5	6	0.6	4	0.4	15	0.8	7	0.7	8	0.8
Post_admission Vital Signs																		
Full set + NEWS calculated	1940	48.5	1018	50.9	922	46.1	910	45.5	479	47.9	431	43.1	1030	51.5	539	53.9	491	49.1
Full set, no NEWS calculated	780	19.5	386	19.3	394	19.7	493	24.7	241	24.1	252	25.2	287	14.4	145	14.5	142	14.2
Incomplete vital signs	301	7.5	147	7.4	154	7.7	170	8.5	83	8.3	87	8.7	131	6.6	64	6.4	67	6.7
No vital signs documented	944	23.6	432	21.6	512	25.6	414	20.7	189	18.9	225	22.5	530	26.5	243	24.3	287	28.7
Missing	35	0.9	17	0.9	18	0.9	13	0.7	8	0.8	5	0.5	22	1.1	9	0.9	13	1.3
Initial specialist review*																		
Specialist review documented in case record	1897	47.4	927	46.4	970	48.5	904	45.2	425	42.5	479	47.9	993	49.7	502	50.2	491	49.1
Probable specialist review but status of doctor uncertain	283	7.1	160	8.0	123	6.2	171	8.6	97	9.7	74	7.4	112	5.6	63	6.3	49	4.9
Unlikely that specialist review occurred	158	4.0	86	4.3	72	3.6	84	4.2	46	4.6	38	3.8	74	3.7	40	4.0	34	3.4
No evidence for specialist review documented	1248	31.2	639	32.0	609	30.5	585	29.3	319	31.9	266	26.6	663	33.2	320	32.0	343	34.3
Specialist review, time not documented, case record suggests > 14 hrs after admission	61	1.5	22	1.1	39	2.0	41	2.1	13	1.3	28	2.8	20	1.0	9	0.9	11	1.1
Specialist review, time not documented, but case record suggests < 14 hrs after admission	314	7.9	147	7.4	167	8.4	197	9.9	89	8.9	108	10.8	117	5.9	58	5.8	59	5.9
Specialist review documented < 14 hrs	1049	26.2	529	26.5	520	26.0	474	23.7	226	22.6	248	24.8	575	28.8	303	30.3	272	27.2
Probable specialist review documented < 14 hrs	140	3.5	78	3.9	62	3.1	78	3.9	47	4.7	31	3.1	62	3.1	31	3.1	31	3.1
Documented + probable specialist review < 14hrs	1189	29.7	607	30.4	582	29.1	552	27.6	273	27.3	279	27.9	637	31.9	334	33.4	303	30.3
Missing	39	1.0	19	1.0	20	1.0	18	0.9	11	1.1	7	0.7	21	1.1	8	0.8	13	1.3
Palliative care discussed																		
No, not required, patient appropriate for full treatment	2907	72.7	1425	71.3	1482	74.1	1471	73.6	718	71.8	753	75.3	1436	71.8	707	70.7	729	72.9
No, but would probably have been appropriate to consider some form of treatment limitation	437	10.9	217	10.9	220	11.0	252	12.6	131	13.1	121	12.1	185	9.3	86	8.6	99	9.9
Yes	275	6.9	163	8.2	112	5.6	112	5.6	70	7.0	42	4.2	163	8.2	93	9.3	70	7.0
No, but would definitely have been appropriate to limit treatment	239	6.0	124	6.2	115	5.8	129	6.5	63	6.3	66	6.6	110	5.5	61	6.1	49	4.9
DNACPR already in place prior to admission	110	2.8	55	2.8	55	2.8	22	1.1	10	1.0	12	1.2	88	4.4	45	4.5	43	4.3
total above 3	**624**	**15.6**	**342**	**17.1**	**282**	**14.1**	**263**	**13.2**	**143**	**14.3**	**120**	**12.0**	**361**	**18.1**	**199**	**19.9**	**162**	**16.2**
Missing	32	0.8	16	0.8	16	0.8	14	0.7	8	0.8	6	0.6	18	0.9	8	0.8	10	1.0
Palliative care decision appropriateness (of those discussed)																		
Yes, appropriate decision	273	99.3	162	99.4	111	99.1	111	99.1	70	100.0	41	97.6	162	99.4	92	98.9	70	100.0
Yes, but patient might have benefited from escalation	1	0.4	0	0.0	1	0.9	1	0.9	0	0.0	1	2.4	0	0.0	0	0.0	0	0.0
Missing	1	0.4	1	0.6	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6	1	1.1	0	0.0
Palliative care referral																		
no	3844	96.1	1912	95.6	1932	96.6	1933	96.7	959	95.9	974	97.4	1911	95.6	953	95.3	958	95.8
yes	87	2.2	51	2.6	36	1.8	36	1.8	23	2.3	13	1.3	51	2.6	28	2.8	23	2.3
Missing	69	1.7	37	1.9	32	1.6	31	1.6	18	1.8	13	1.3	38	1.9	19	1.9	19	1.9
Admission avoidable																		
no	2919	73.0	1498	74.9	1421	71.1	1475	73.8	749	74.9	726	72.6	1444	72.2	749	74.9	695	69.5
possibly	783	19.6	361	18.1	422	21.1	388	19.4	184	18.4	204	20.4	395	19.8	177	17.7	218	21.8
yes	269	6.7	124	6.2	145	7.3	127	6.4	59	5.9	68	6.8	142	7.1	65	6.5	77	7.7
Missing	29	0.7	17	0.9	12	0.6	10	0.5	8	0.8	2	0.2	19	1.0	9	0.9	10	1.0

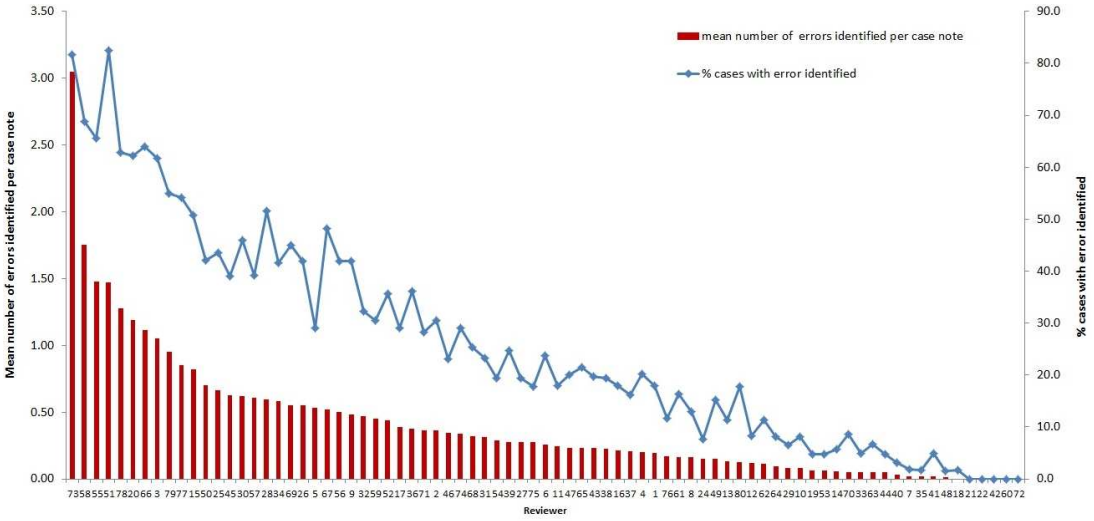
*Categories in this section are not mutually exclusive

ESM Table 4: Reviewers' assessment on error, adverse events, and global quality of care

	BOTH EPOCHS						EPOCH 1						EPOCH 2					
	Total		W/E		W/D		Total		W/E		W/D		Total		W/E		W/D	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total	**4000**		**2000**		**2000**		**2000**		**1000**		**1000**		**2000**		**1000**		**1000**	
Number of errors																		
No error	2970	74.3	1486	74.3	1484	74.2	1447	72.4	723	72.3	724	72.4	1523	76.2	763	76.3	760	76.0
1	645	16.1	328	16.4	317	15.9	338	16.9	178	17.8	160	16.0	307	15.4	150	15.0	157	15.7
2	208	5.2	100	5.0	108	5.4	121	6.1	53	5.3	68	6.8	87	4.4	47	4.7	40	4.0
3	83	2.1	36	1.8	47	2.4	43	2.2	18	1.8	25	2.5	40	2.0	18	1.8	22	2.2
4	31	0.8	17	0.9	14	0.7	22	1.1	12	1.2	10	1.0	9	0.5	5	0.5	4	0.4
5	13	0.3	9	0.5	4	0.2	7	0.4	5	0.5	2	0.2	6	0.3	4	0.4	2	0.2
6	9	0.2	4	0.2	5	0.3	4	0.2	1	0.1	3	0.3	5	0.3	3	0.3	2	0.2
7	3	0.1	1	0.1	2	0.1	2	0.1	0	0.0	2	0.2	1	0.1	1	0.1	0	0.0
8	2	0.1	1	0.1	1	0.1	2	0.1	1	0.1	1	0.1	0	0.0	0	0.0	0	0.0
13	1	0.0	0	0.0	1	0.1	1	0.1	0	0.0	1	0.1	0	0.0	0	0.0	0	0.0
15	1	0.0	1	0.1	0	0.0	1	0.1	1	0.1	0	0.0	0	0.0	0	0.0	0	0.0
Missing	34	0.9	17	0.9	17	0.9	12	0.6	8	0.8	4	0.4	22	1.1	9	0.9	13	1.3
Error in care																		
Yes	996	24.9	497	24.9	499	25.0	541	27.1	269	26.9	272	27.2	455	22.8	228	22.8	227	22.7
No	2970	74.3	1486	74.3	1484	74.2	1447	72.4	723	72.3	724	72.4	1523	76.2	763	76.3	760	76.0
Missing	34	0.9	17	0.9	17	0.9	12	0.6	8	0.8	4	0.4	22	1.1	9	0.9	13	1.3
Total number of errors	1618		803		815		914		440		474		704		363		341	
Mean number of errors per patient admission (total number of errors / number of patient admission excluding errors unknown)	0.408		0.405		0.41		0.46		0.444		0.476		0.36		0.37		0.35	
Location of errors*	1617		802		815		914		440		474		703		362		341	
1, Outside hospital (primary care , ambulance etc)	31	1.9	11	1.4	20	2.5	16	1.8	7	1.6	9	1.9	15	2.1	4	1.1	11	3.2
2, In the ED or linked area before admission	554	34.3	298	37.2	256	31.4	310	33.9	167	38.0	143	30.2	244	34.7	131	36.2	113	33.1
3, AMU or equivalent area	554	34.3	255	31.8	299	36.7	312	34.1	134	30.5	178	37.6	242	34.4	121	33.4	121	35.5
4, Acute ward (other than AMU)	294	18.2	158	19.7	136	16.7	170	18.6	87	19.8	83	17.5	124	17.6	71	19.6	53	15.5
5, Speciality (ICU / HDU, coronary care, renal, respiratory, elderly care, rehab)	174	10.8	74	9.2	100	12.3	102	11.2	42	9.5	60	12.7	72	10.2	32	8.8	40	11.7
6, Diagnostic area, radiology	10	0.6	6	0.7	4	0.5	4	0.4	3	0.7	1	0.2	6	0.9	3	0.8	3	0.9
Error typology	2409		1208		1201		1391		681		710		1018		527		491	
1, Assessment	768	31.9	379	31.4	389	32.4	446	32.1	214	31.4	232	32.7	322	31.6	165	31.3	157	32.0
2, Medication	317	13.2	157	13.0	160	13.3	191	13.7	98	14.4	93	13.1	126	12.4	59	11.2	67	13.6
3, Treatment and management	702	29.1	346	28.6	356	29.6	406	29.2	193	28.3	213	30.0	296	29.1	153	29.0	143	29.1
4, Infection control	18	0.7	8	0.7	10	0.8	5	0.4	2	0.3	3	0.4	13	1.3	6	1.1	7	1.4
5, Invasive procedures	25	1.0	15	1.2	10	0.8	17	1.2	10	1.5	7	1.0	8	0.8	5	0.9	3	0.6
6, Monitoring	114	4.7	57	4.7	57	4.7	64	4.6	33	4.8	31	4.4	50	4.9	24	4.6	26	5.3
7, Resuscitation	29	1.2	22	1.8	7	0.6	16	1.2	12	1.8	4	0.6	13	1.3	10	1.9	3	0.6
8, Communication	369	15.3	188	15.6	181	15.1	202	14.5	96	14.1	106	14.9	167	16.4	92	17.5	75	15.3
9, Other	67	2.8	36	3.0	31	2.6	44	3.2	23	3.4	21	3.0	23	2.3	13	2.5	10	2.0
Mean number of error typology of each category per patient admission	0.607		0.609		0.606		0.700		0.686		0.713		0.515		0.532		0.497	
1, Assessment	0.194		0.191		0.196		0.224		0.216		0.233		0.16		0.17		0.16	
2, Medication	0.080		0.079		0.081		0.096		0.099		0.093		0.06		0.06		0.07	
3, Treatment and management	0.177		0.174		0.180		0.204		0.195		0.214		0.15		0.15		0.14	
4, Infection control	0.005		0.004		0.005		0.003		0.002		0.003		0.01		0.01		0.01	
5, Invasive procedures	0.006		0.008		0.005		0.009		0.01		0.007		0		0.01		0	
6, Monitoring	0.029		0.029		0.029		0.032		0.033		0.031		0.03		0.02		0.03	
7, Resuscitation	0.007		0.011		0.004		0.008		0.012		0.004		0.01		0.01		0	
8, Communication	0.093		0.095		0.091		0.102		0.097		0.106		0.08		0.09		0.08	
9, Other	0.017		0.018		0.016		0.022		0.023		0.021		0.01		0.01		0.010	
Error associated with adverse event																		
Yes	128	7.9	58	7.2	70	8.6	91	10.0	39	8.9	52	11.0	37	5.3	19	5.2	18	5.3
No	757	46.8	370	46.1	387	47.5	405	44.3	192	43.6	213	44.9	352	50.0	178	49.0	174	51.0
Insufficient evidence	733	45.3	375	46.7	358	43.9	418	45.7	209	47.5	209	44.1	315	44.7	166	45.7	149	43.7
Preventability of adverse event (of those associated with adverse event)																		
1, Virtually no evidence for preventability	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2, Slight to modest evidence of preventability	16	12.5	11	8.6	5	3.9	16	12.5	11	8.6	5	3.9	0	0.0	0	0.0	0	0.0
1&2	16	12.5	11	8.6	5	3.9	16	12.5	11	8.6	5	3.9	0	0.0	0	0.0	0	0.0
3, Possibly preventable, but not very likely (less than 50-50, but close call)	21	16.4	7	5.5	14	10.9	12	9.4	3	2.3	9	7.0	9	7.0	4	3.1	5	3.9
4, Probably preventable (more than 50-50, but a close call)	26	20.3	12	9.4	14	10.9	21	16.4	9	7.0	12	9.4	5	3.9	3	2.3	2	1.6
3 & 4	47	36.7	19	14.8	28	21.9	33	25.8	12	9.4	21	16.4	14	10.9	7	5.5	7	5.5
5, Strong evidence for preventability	41	32.0	14	10.9	27	21.1	28	21.9	9	7.0	19	14.8	13	10.2	5	3.9	8	6.3
6, Virtually certain evidence of preventability	24	18.8	14	10.9	10	7.8	14	10.9	7	5.5	7	5.5	10	7.8	7	5.5	3	2.3
5 & 6	65	50.8	28	21.9	37	28.9	42	32.8	16	12.5	26	20.3	23	18.0	12	9.4	11	8.6
Global assessment																		
1, Completely	1579	39.5	778	38.9	801	40.1	751	37.6	366	36.6	385	38.5	828	41.4	412	41.2	416	41.6
2, Substantially	1659	41.5	846	42.3	813	40.7	837	41.9	435	43.5	402	40.2	822	41.1	411	41.1	411	41.1
1 & 2	3238	81.0	1624	81.2	1614	80.7	1588	79.4	801	80.1	787	78.7	1650	82.5	823	82.3	827	82.7
3, Partially	623	15.6	303	15.2	320	16.0	333	16.7	159	15.9	174	17.4	290	14.5	144	14.4	146	14.6
4, Very little	83	2.1	43	2.2	40	2.0	56	2.8	27	2.7	29	2.9	27	1.4	16	1.6	11	1.1
5, Not at all	23	0.6	12	0.6	11	0.6	8	0.4	3	0.3	5	0.5	15	0.8	9	0.9	6	0.6
4 & 5	106	2.7	55	2.8	51	2.6	64	3.2	30	3.0	34	3.4	42	2.1	25	2.5	17	1.7
Missing	33	0.8	18	0.9	15	0.8	15	0.8	10	1.0	5	0.5	18	0.9	8	0.8	10	1.0

*one error had no information on location

ESM Figure 1: Mean number of errors identified per case notes by reviewer



APPENDIX 2 - ELECTRONIC SUPLEMENTARY MATERIAL (ESM)

ESM Table 1: Status of 20 participating Trusts in 2014

Trust	Size (number of beds, range)	Quintile (based on number of beds)	Specialist hours per 10 Emergency Admissions*
1	986-2037	**5**	40.2
2			34.1
3			15.5
4			10.7
5	787-984	**4**	38.9
6			36.1
7			18.5
8			15.4
9	636-783	**3**	50.7
10			35.7
11			11.4
12			8.1
13	479-627	**2**	47.0
14			38.0
15			9.6
16			7.0
17	240-470	**1**	38.6
18			34.7
19			11.1
20			8.8

*Adjusted using the formulae N x (1 / Response Rate) and rounded to the nearest integer

ESM Table 2: Characteristics of study population versus background population

	Case Notes Review data						All trusts/hositals data*					
	Total		W/E		W/D		Total		W/E		W/D	
	n	%	n	%	n	%	n	%	n	%	n	%
Total	4000		2000		2000		5818430		1411394		4407036	
Age												
Mean (SD)	61.1	22.310	61.7	22.379	60.5	22.271	61	22.350	61	22.780	61	22.190
Median (IQR)	65	43-81	66	44-81	64	42-80	65	43-80	66	43-81	65	43-80
Gender												
Male	1869	46.7	938	46.9	931	46.6	2639489	45.4	645166	45.7	1994323	45.3
Female	2131	53.3	1062	53.1	1069	53.5	3178941	54.6	766228	54.3	2412713	54.7
Ethnicity												
Caucasian	3140	78.5	1584	79.2	1556	77.8	4918775	84.5	1191464	84.4	3727311	84.6
Non_Caucasian	818	20.5	396	19.8	422	21.1	526384	9.0	128736	9.1	397648	9.0
Unknown	42	1.1	20	1.0	22	1.1	373271	6.4	91194	6.5	282077	6.4
Top 5 primary discharge diagnosis (SHMI grouping)												
Nonspecific chest pain	227	5.7	116	5.8	111	5.6	326876	5.6	72314	5.1	254562	5.8
Pneumonia (excluding TB/STD)	186	4.7	105	5.3	81	4.1	322014	5.5	85643	6.1	236371	5.4
Urinary tract infections	176	4.4	100	5.0	76	3.8	235612	4.0	64076	4.5	171536	3.9
Abdominal pain	156	3.9	70	3.5	86	4.3	243013	4.2	54697	3.9	188316	4.3
COPD & bronchiectasis	128	3.2	67	3.4	61	3.1	193168	3.3	48288	3.4	144880	3.3
Other	3127	78.2	1542	77.1	1585	79.3	4497747	77.3	1086376	77.0	3411371	77.4
Length of stay												
median (IQR)	2	0-5	2	0-5	1	0-4	1	0-5	2	0-5	1	0-5
Zero length of stay												
ZLOS	1107	27.7	512	25.6	595	29.8	1739129	29.9	388274	27.5	1350757	30.7
Not-ZLOS	2871	71.8	1477	73.9	1394	69.7	4078719	70.1	1023261	72.5	3054076	69.3
Unknown	22	0.6	11	0.6	11	0.6	0	0.0	0	0.0	0	0.0
In-hospital mortality												
Died	168	4.2	90	4.5	78	3.9	239719	4.1	63372	4.5	176281	4.0

*from Hospital Episode Statistics (HES), of those trusts participating in HiSLAC speciality intensity prevalence survey from 2014 to 2018 financial years

ESM Table 3a: Reviewers' assessment on pre-admission patient pathways

	BOTH EPOCHS						EPOCH 1						EPOCH 2					
	Total		W/E		W/D		Total		W/E		W/D		Total		W/E		W/D	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total	**4000**		**2000**		**2000**		**2000**		**1000**		**1000**		**2000**		**1000**		**1000**	
Source of admission																		
Own home	3389	84.7	1711	85.6	1678	83.9	1712	85.6	865	86.5	847	84.7	1677	83.9	846	84.6	831	83.1
Nursing or residential care home	257	6.4	121	6.1	136	6.8	127	6.4	60	6.0	67	6.7	130	6.5	61	6.1	69	6.9
No information available	247	6.2	114	5.7	133	6.7	105	5.3	46	4.6	59	5.9	142	7.1	68	6.8	74	7.4
Another hospital	30	0.8	16	0.8	14	0.7	12	0.6	6	0.6	6	0.6	18	0.9	10	1.0	8	0.8
No fixed abode	70	1.8	34	1.7	36	1.8	41	2.1	21	2.1	20	2.0	29	1.5	13	1.3	16	1.6
Missing	7	0.2	4	0.2	3	0.2	3	0.2	2	0.2	1	0.1	4	0.2	2	0.2	2	0.2
Patient condition before admission																		
Independent	2611	65.3	1292	64.6	1319	66.0	1333	66.7	667	66.7	666	66.6	1278	63.9	625	62.5	653	65.3
Needing help with some activities of daily living (ADLs)	672	16.8	332	16.6	340	17.0	351	17.6	169	16.9	182	18.2	321	16.1	163	16.3	158	15.8
Dependant on others for most/all ADLs including personal hygiene	384	9.6	219	11.0	165	8.3	174	8.7	100	10.0	74	7.4	210	10.5	119	11.9	91	9.1
Unable to determine; no relevant information in notes	325	8.1	152	7.6	173	8.7	139	7.0	62	6.2	77	7.7	186	9.3	90	9.0	96	9.6
Missing	8	0.2	5	0.3	3	0.2	3	0.2	2	0.2	1	0.1	5	0.3	3	0.3	2	0.2
Referral to hospital mechanism																		
999/ambulance transfer to ED	1873	46.8	1032	51.6	841	42.1	995	49.8	550	55.0	445	44.5	878	43.9	482	48.2	396	39.6
Self-presentation to ED (walk-in/own transport)	847	21.2	455	22.8	392	19.6	402	20.1	215	21.5	187	18.7	445	22.3	240	24.0	205	20.5
GP or deputising service referral (documented letter or phone call)	559	14.0	164	8.2	395	19.8	288	14.4	88	8.8	200	20.0	271	13.6	76	7.6	195	19.5
Unable to determine	553	13.8	282	14.1	271	13.6	236	11.8	123	12.3	113	11.3	317	15.9	159	15.9	158	15.8
Patient instructed by GP to attend ED, no formal evidence of referral	93	2.3	29	1.5	64	3.2	51	2.6	16	1.6	35	3.5	42	2.1	13	1.3	29	2.9
Urgent Care Centre or Walk-In Centre referral	45	1.1	26	1.3	19	1.0	16	0.8	4	0.4	12	1.2	29	1.5	22	2.2	7	0.7
Self-presentation, patient instructed to attend by 111 service	20	0.5	7	0.4	13	0.7	7	0.4	2	0.2	5	0.5	13	0.7	5	0.5	8	0.8
Missing	10	0.3	5	0.3	5	0.3	5	0.3	2	0.2	3	0.3	5	0.3	3	0.3	2	0.2
Admission pathway																		
ED / pre-admission area	3354	83.9	1757	87.9	1597	79.9	1664	83.2	870	87.0	794	79.4	1690	84.5	887	88.7	803	80.3
Direct admission to acute ward	451	11.3	160	8.0	291	14.6	247	12.4	93	9.3	154	15.4	204	10.2	67	6.7	137	13.7
Unable to determine	187	4.7	78	3.9	109	5.5	86	4.3	35	3.5	51	5.1	101	5.1	43	4.3	58	5.8
(blank)	8	0.2	5	0.3	3	0.2	3	0.2	2	0.2	1	0.1	5	0.3	3	0.3	2	0.2
Pre_admission Vital Signs																		
Full set + NEWS calculated	1765	44.1	914	45.7	851	42.6	761	38.1	395	39.5	366	36.6	1004	50.2	519	51.9	485	48.5
Full set, no NEWS calculated	1282	32.1	656	32.8	626	31.3	781	39.1	391	39.1	390	39.0	501	25.1	265	26.5	236	23.6
Incomplete vital signs	322	8.1	160	8.0	162	8.1	187	9.4	91	9.1	96	9.6	135	6.8	69	6.9	66	6.6
No vital signs documented	365	9.1	180	9.0	185	9.3	133	6.7	71	7.1	62	6.2	232	11.6	109	10.9	123	12.3
Not applicable: patient not admitted via ED: direct admission to ward	253	6.3	81	4.1	172	8.6	133	6.7	48	4.8	85	8.5	120	6.0	33	3.3	87	8.7
Missing	13	0.3	9	0.5	4	0.2	5	0.3	4	0.4	1	0.1	8	0.4	5	0.5	3	0.3

ESM Table 3b: Reviewers' assessments of post-admission pathways & care processes

	BOTH EPOCHS						EPOCH 1						EPOCH 2					
	Total		W/E		W/D		Total		W/E		W/D		Total		W/E		W/D	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total	**4000**		**2000**		**2000**		**2000**		**1000**		**1000**		**2000**		**1000**		**1000**	
1st location post admission																		
Acute Medical Unit (AMU/MAU)	1401	35.0	690	34.5	711	35.6	704	35.2	327	32.7	377	37.7	697	34.9	363	36.3	334	33.4
Unable to determine ward type	655	16.4	319	16.0	336	16.8	317	15.9	164	16.4	153	15.3	338	16.9	155	15.5	183	18.3
Clinical Decision Unit or short stay ward	659	16.5	356	17.8	303	15.2	353	17.7	187	18.7	166	16.6	306	15.3	169	16.9	137	13.7
Other (please specify):	422	10.6	196	9.8	226	11.3	200	10.0	103	10.3	97	9.7	222	11.1	93	9.3	129	12.9
General Surgery (including surgical assessment/operating theatre)	376	9.4	193	9.7	183	9.2	179	9.0	99	9.9	80	8.0	197	9.9	94	9.4	103	10.3
Medical sub-specialities including high care (eg: Coronary Care Unit, Renal Unit, Respiratory, Haematology, Oncology)	215	5.4	103	5.2	112	5.6	116	5.8	47	4.7	69	6.9	99	5.0	56	5.6	43	4.3
General medical ward	171	4.3	84	4.2	87	4.4	88	4.4	47	4.7	41	4.1	83	4.2	37	3.7	46	4.6
Older Peoples Medicine/Elderly Care Unit	46	1.2	27	1.4	19	1.0	19	1.0	11	1.1	8	0.8	27	1.4	16	1.6	11	1.1
Critical Care Unit / Intensive Care Unit (including High Dependency)	33	0.8	20	1.0	13	0.7	18	0.9	11	1.1	7	0.7	15	0.8	9	0.9	6	0.6
Missing	18	0.5	10	0.5	8	0.4	5	0.3	3	0.3	2	0.2	13	0.7	7	0.7	6	0.6
Rehabilitation	4	0.1	2	0.1	2	0.1	1	0.1	1	0.1	0	0.0	3	0.2	1	0.1	2	0.2
Location appropriateness																		
Yes, definitely appropriate	2469	61.7	1215	60.8	1254	62.7	1234	61.7	602	60.2	632	63.2	1235	61.8	613	61.3	622	62.2
Probably appropriate	854	21.4	443	22.2	411	20.6	455	22.8	235	23.5	220	22.0	399	20.0	208	20.8	191	19.1
Unable to determine	534	13.4	270	13.5	264	13.2	240	12.0	128	12.8	112	11.2	294	14.7	142	14.2	152	15.2
No	118	3.0	59	3.0	59	3.0	61	3.1	29	2.9	32	3.2	57	2.9	30	3.0	27	2.7
Missing	25	0.6	13	0.7	12	0.6	10	0.5	6	0.6	4	0.4	15	0.8	7	0.7	8	0.8
Post_admission Vital Signs																		
Full set + NEWS calculated	1940	48.5	1018	50.9	922	46.1	910	45.5	479	47.9	431	43.1	1030	51.5	539	53.9	491	49.1
Full set, no NEWS calculated	780	19.5	386	19.3	394	19.7	493	24.7	241	24.1	252	25.2	287	14.4	145	14.5	142	14.2
Incomplete vital signs	301	7.5	147	7.4	154	7.7	170	8.5	83	8.3	87	8.7	131	6.6	64	6.4	67	6.7
No vital signs documented	944	23.6	432	21.6	512	25.6	414	20.7	189	18.9	225	22.5	530	26.5	243	24.3	287	28.7
Missing	35	0.9	17	0.9	18	0.9	13	0.7	8	0.8	5	0.5	22	1.1	9	0.9	13	1.3
Initial specialist review*																		
Specialist review documented in case record	1897	47.4	927	46.4	970	48.5	904	45.2	425	42.5	479	47.9	993	49.7	502	50.2	491	49.1
Probable specialist review but status of doctor uncertain	283	7.1	160	8.0	123	6.2	171	8.6	97	9.7	74	7.4	112	5.6	63	6.3	49	4.9
Unlikely that specialist review occurred	158	4.0	86	4.3	72	3.6	84	4.2	46	4.6	38	3.8	74	3.7	40	4.0	34	3.4
No evidence for specialist review documented	1248	31.2	639	32.0	609	30.5	585	29.3	319	31.9	266	26.6	663	33.2	320	32.0	343	34.3
Specialist review, time not documented, case record suggests > 14 hrs after admission	61	1.5	22	1.1	39	2.0	41	2.1	13	1.3	28	2.8	20	1.0	9	0.9	11	1.1
Specialist review, time not documented, but case record suggests < 14 hrs after admission	314	7.9	147	7.4	167	8.4	197	9.9	89	8.9	108	10.8	117	5.9	58	5.8	59	5.9
Specialist review documented < 14 hrs	1049	26.2	529	26.5	520	26.0	474	23.7	226	22.6	248	24.8	575	28.8	303	30.3	272	27.2
Probable specialist review documented < 14 hrs	140	3.5	78	3.9	62	3.1	78	3.9	47	4.7	31	3.1	62	3.1	31	3.1	31	3.1
Documented + probable specialist review < 14hrs	1189	29.7	607	30.4	582	29.1	552	27.6	273	27.3	279	27.9	637	31.9	334	33.4	303	30.3
Missing	39	1.0	19	1.0	20	1.0	18	0.9	11	1.1	7	0.7	21	1.1	8	0.8	13	1.3
Palliative care discussed																		
No, not required, patient appropriate for full treatment	2907	72.7	1425	71.3	1482	74.1	1471	73.6	718	71.8	753	75.3	1436	71.8	707	70.7	729	72.9
No, but would probably have been appropriate to consider some form of treatment limitation	437	10.9	217	10.9	220	11.0	252	12.6	131	13.1	121	12.1	185	9.3	86	8.6	99	9.9
Yes	275	6.9	163	8.2	112	5.6	112	5.6	70	7.0	42	4.2	163	8.2	93	9.3	70	7.0
No, but would definitely have been appropriate to limit treatment	239	6.0	124	6.2	115	5.8	129	6.5	63	6.3	66	6.6	110	5.5	61	6.1	49	4.9
DNACPR already in place prior to admission	110	2.8	55	2.8	55	2.8	22	1.1	10	1.0	12	1.2	88	4.4	45	4.5	43	4.3
total above 3	**624**	**15.6**	**342**	**17.1**	**282**	**14.1**	**263**	**13.2**	**143**	**14.3**	**120**	**12.0**	**361**	**18.1**	**199**	**19.9**	**162**	**16.2**
Missing	32	0.8	16	0.8	16	0.8	14	0.7	8	0.8	6	0.6	18	0.9	8	0.8	10	1.0
Palliative care decision appropriateness (of those discussed)																		
Yes, appropriate decision	273	99.3	162	99.4	111	99.1	111	99.1	70	100.0	41	97.6	162	99.4	92	98.9	70	100.0
Yes, but patient might have benefited from escalation	1	0.4	0	0.0	1	0.9	1	0.9	0	0.0	1	2.4	0	0.0	0	0.0	0	0.0
Missing	1	0.4	1	0.6	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6	1	1.1	0	0.0
Palliative care referral																		
no	3844	96.1	1912	95.6	1932	96.6	1933	96.7	959	95.9	974	97.4	1911	95.6	953	95.3	958	95.8
yes	87	2.2	51	2.6	36	1.8	36	1.8	23	2.3	13	1.3	51	2.6	28	2.8	23	2.3
Missing	69	1.7	37	1.9	32	1.6	31	1.6	18	1.8	13	1.3	38	1.9	19	1.9	19	1.9
Admission avoidable																		
no	2919	73.0	1498	74.9	1421	71.1	1475	73.8	749	74.9	726	72.6	1444	72.2	749	74.9	695	69.5
possibly	783	19.6	361	18.1	422	21.1	388	19.4	184	18.4	204	20.4	395	19.8	177	17.7	218	21.8
yes	269	6.7	124	6.2	145	7.3	127	6.4	59	5.9	68	6.8	142	7.1	65	6.5	77	7.7
Missing	29	0.7	17	0.9	12	0.6	10	0.5	8	0.8	2	0.2	19	1.0	9	0.9	10	1.0

*Categories in this section are not mutually exclusive

ESM Table 4: Reviewers' assessment on error, adverse events, and global quality of care

	BOTH EPOCHS						EPOCH 1						EPOCH 2					
	Total		W/E		W/D		Total		W/E		W/D		Total		W/E		W/D	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total	**4000**		**2000**		**2000**		**2000**		**1000**		**1000**		**2000**		**1000**		**1000**	
Number of errors																		
No error	2970	74.3	1486	74.3	1484	74.2	1447	72.4	723	72.3	724	72.4	1523	76.2	763	76.3	760	76.0
1	645	16.1	328	16.4	317	15.9	338	16.9	178	17.8	160	16.0	307	15.4	150	15.0	157	15.7
2	208	5.2	100	5.0	108	5.4	121	6.1	53	5.3	68	6.8	87	4.4	47	4.7	40	4.0
3	83	2.1	36	1.8	47	2.4	43	2.2	18	1.8	25	2.5	40	2.0	18	1.8	22	2.2
4	31	0.8	17	0.9	14	0.7	22	1.1	12	1.2	10	1.0	9	0.5	5	0.5	4	0.4
5	13	0.3	9	0.5	4	0.2	7	0.4	5	0.5	2	0.2	6	0.3	4	0.4	2	0.2
6	9	0.2	4	0.2	5	0.3	4	0.2	1	0.1	3	0.3	5	0.3	3	0.3	2	0.2
7	3	0.1	1	0.1	2	0.1	2	0.1	0	0.0	2	0.2	1	0.1	1	0.1	0	0.0
8	2	0.1	1	0.1	1	0.1	2	0.1	1	0.1	1	0.1	0	0.0	0	0.0	0	0.0
13	1	0.0	0	0.0	1	0.1	1	0.1	0	0.0	1	0.1	0	0.0	0	0.0	0	0.0
15	1	0.0	1	0.1	0	0.0	1	0.1	1	0.1	0	0.0	0	0.0	0	0.0	0	0.0
Missing	34	0.9	17	0.9	17	0.9	12	0.6	8	0.8	4	0.4	22	1.1	9	0.9	13	1.3
Error in care																		
Yes	996	24.9	497	24.9	499	25.0	541	27.1	269	26.9	272	27.2	455	22.8	228	22.8	227	22.7
No	2970	74.3	1486	74.3	1484	74.2	1447	72.4	723	72.3	724	72.4	1523	76.2	763	76.3	760	76.0
Missing	34	0.9	17	0.9	17	0.9	12	0.6	8	0.8	4	0.4	22	1.1	9	0.9	13	1.3
Total number of errors	1618		803		815		914		440		474		704		363		341	
Mean number of errors per patient admission (total number of errors / number of patient admission excluding errors unknown)	0.408		0.405		0.41		0.46		0.444		0.476		0.36		0.37		0.35	
Location of errors*	1617		802		815		914		440		474		703		362		341	
1, Outside hospital (primary care , ambulance etc)	31	1.9	11	1.4	20	2.5	16	1.8	7	1.6	9	1.9	15	2.1	4	1.1	11	3.2
2, In the ED or linked area before admission	554	34.3	298	37.2	256	31.4	310	33.9	167	38.0	143	30.2	244	34.7	131	36.2	113	33.1
3, AMU or equivalent area	554	34.3	255	31.8	299	36.7	312	34.1	134	30.5	178	37.6	242	34.4	121	33.4	121	35.5
4, Acute ward (other than AMU)	294	18.2	158	19.7	136	16.7	170	18.6	87	19.8	83	17.5	124	17.6	71	19.6	53	15.5
5, Speciality (ICU / HDU, coronary care, renal, respiratory, elderly care, rehab)	174	10.8	74	9.2	100	12.3	102	11.2	42	9.5	60	12.7	72	10.2	32	8.8	40	11.7
6, Diagnostic area, radiology	10	0.6	6	0.7	4	0.5	4	0.4	3	0.7	1	0.2	6	0.9	3	0.8	3	0.9
Error typology	2409		1208		1201		1391		681		710		1018		527		491	
1, Assessment	768	31.9	379	31.4	389	32.4	446	32.1	214	31.4	232	32.7	322	31.6	165	31.3	157	32.0
2, Medication	317	13.2	157	13.0	160	13.3	191	13.7	98	14.4	93	13.1	126	12.4	59	11.2	67	13.6
3, Treatment and management	702	29.1	346	28.6	356	29.6	406	29.2	193	28.3	213	30.0	296	29.1	153	29.0	143	29.1
4, Infection control	18	0.7	8	0.7	10	0.8	5	0.4	2	0.3	3	0.4	13	1.3	6	1.1	7	1.4
5, Invasive procedures	25	1.0	15	1.2	10	0.8	17	1.2	10	1.5	7	1.0	8	0.8	5	0.9	3	0.6
6, Monitoring	114	4.7	57	4.7	57	4.7	64	4.6	33	4.8	31	4.4	50	4.9	24	4.6	26	5.3
7, Resuscitation	29	1.2	22	1.8	7	0.6	16	1.2	12	1.8	4	0.6	13	1.3	10	1.9	3	0.6
8, Communication	369	15.3	188	15.6	181	15.1	202	14.5	96	14.1	106	14.9	167	16.4	92	17.5	75	15.3
9, Other	67	2.8	36	3.0	31	2.6	44	3.2	23	3.4	21	3.0	23	2.3	13	2.5	10	2.0
Mean number of error typology of each category per patient admission	0.607		0.609		0.606		0.700		0.686		0.713		0.515		0.532		0.497	
1, Assessment	0.194		0.191		0.196		0.224		0.216		0.233		0.16		0.17		0.16	
2, Medication	0.080		0.079		0.081		0.096		0.099		0.093		0.06		0.06		0.07	
3, Treatment and management	0.177		0.174		0.180		0.204		0.195		0.214		0.15		0.15		0.14	
4, Infection control	0.005		0.004		0.005		0.003		0.002		0.003		0.01		0.01		0.01	
5, Invasive procedures	0.006		0.008		0.005		0.009		0.01		0.007		0		0.01		0	
6, Monitoring	0.029		0.029		0.029		0.032		0.033		0.031		0.03		0.02		0.03	
7, Resuscitation	0.007		0.011		0.004		0.008		0.012		0.004		0.01		0.01		0	
8, Communication	0.093		0.095		0.091		0.102		0.097		0.106		0.08		0.09		0.08	
9, Other	0.017		0.018		0.016		0.022		0.023		0.021		0.01		0.01		0.010	
Error associated with adverse event																		
Yes	128	7.9	58	7.2	70	8.6	91	10.0	39	8.9	52	11.0	37	5.3	19	5.2	18	5.3
No	757	46.8	370	46.1	387	47.5	405	44.3	192	43.6	213	44.9	352	50.0	178	49.0	174	51.0
Insufficient evidence	733	45.3	375	46.7	358	43.9	418	45.7	209	47.5	209	44.1	315	44.7	166	45.7	149	43.7
Preventability of adverse event (of those associated with adverse event)																		
1, Virtually no evidence for preventability	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2, Slight to modest evidence of preventability	16	12.5	11	8.6	5	3.9	16	12.5	11	8.6	5	3.9	0	0.0	0	0.0	0	0.0
1&2	16	12.5	11	8.6	5	3.9	16	12.5	11	8.6	5	3.9	0	0.0	0	0.0	0	0.0
3, Possibly preventable, but not very likely (less than 50-50, but close call)	21	16.4	7	5.5	14	10.9	12	9.4	3	2.3	9	7.0	9	7.0	4	3.1	5	3.9
4, Probably preventable (more than 50-50, but a close call)	26	20.3	12	9.4	14	10.9	21	16.4	9	7.0	12	9.4	5	3.9	3	2.3	2	1.6
3 & 4	47	36.7	19	14.8	28	21.9	33	25.8	12	9.4	21	16.4	14	10.9	7	5.5	7	5.5
5, Strong evidence for preventability	41	32.0	14	10.9	27	21.1	28	21.9	9	7.0	19	14.8	13	10.2	5	3.9	8	6.3
6, Virtually certain evidence of preventability	24	18.8	14	10.9	10	7.8	14	10.9	7	5.5	7	5.5	10	7.8	7	5.5	3	2.3
5 & 6	65	50.8	28	21.9	37	28.9	42	32.8	16	12.5	26	20.3	23	18.0	12	9.4	11	8.6
Global assessment																		
1, Completely	1579	39.5	778	38.9	801	40.1	751	37.6	366	36.6	385	38.5	828	41.4	412	41.2	416	41.6
2, Substantially	1659	41.5	846	42.3	813	40.7	837	41.9	435	43.5	402	40.2	822	41.1	411	41.1	411	41.1
1 & 2	3238	81.0	1624	81.2	1614	80.7	1588	79.4	801	80.1	787	78.7	1650	82.5	823	82.3	827	82.7
3, Partially	623	15.6	303	15.2	320	16.0	333	16.7	159	15.9	174	17.4	290	14.5	144	14.4	146	14.6
4, Very little	83	2.1	43	2.2	40	2.0	56	2.8	27	2.7	29	2.9	27	1.4	16	1.6	11	1.1
5, Not at all	23	0.6	12	0.6	11	0.6	8	0.4	3	0.3	5	0.5	15	0.8	9	0.9	6	0.6
4 & 5	106	2.7	55	2.8	51	2.6	64	3.2	30	3.0	34	3.4	42	2.1	25	2.5	17	1.7
Missing	33	0.8	18	0.9	15	0.8	15	0.8	10	1.0	5	0.5	18	0.9	8	0.8	10	1.0

*one error had no information on location

ESM Figure 1: Mean number of errors identified per case notes by reviewer