Exploring the association between A&E performance and bed occupancy using Hospital Episode Statistics

Summary

This paper sets out how we used Hospital Episode Statistics (HES) to explore measures of A&E departments' performance and, in particular, their association with measures of bed pressure (**Figure 1**).

Background

The National Audit Office's (NAO) previous report on *Emergency admissions to hospital* discussed the relationship between performance against the 4-hour A&E standard and admission patterns.[1] It showed that a quarter of emergency admissions from A&E departments occur within the last 10 minutes of this 4-hour period. This suggests that delaying admissions until the end of the 4-hour period could be a mechanism for managing limited bed capacity.

A recent trend of declining performance against the A&E 4-hour standard has been documented nationally. Constraints to patient flow across a hospital have been one of the potential causes cited.[2] However, it is unclear if bed pressure is undermining wider measures of A&E performance.
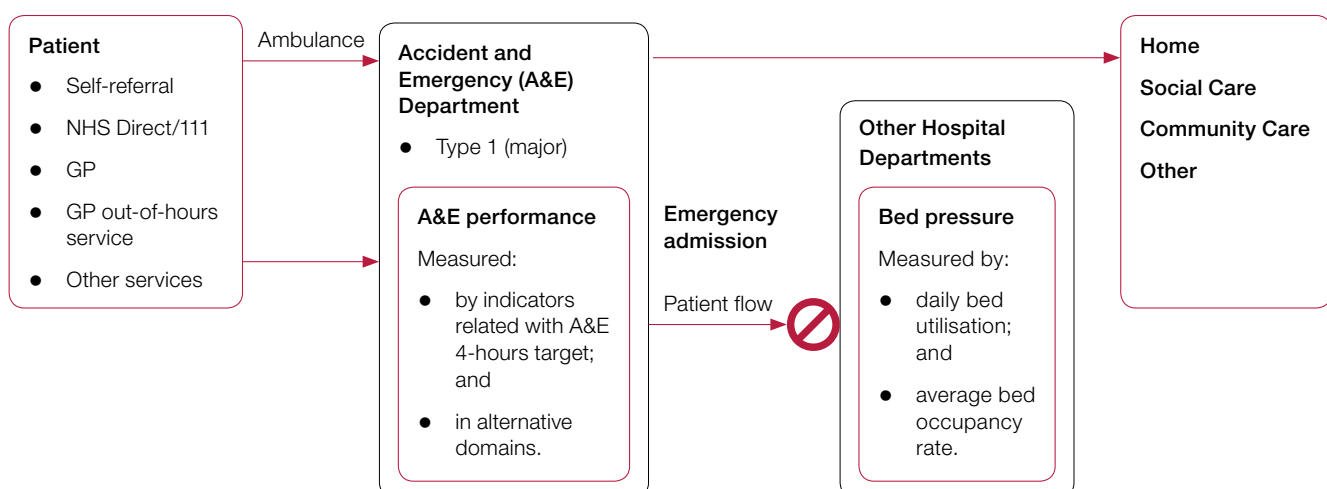
Data

HES provide comprehensive episode-level data for hospital services, including an anonymised patient identifier. We used the HES A&E dataset to derive A&E performance measures at the episode-level (dependent variables) and some control variables. The HES admitted patient care (APC) dataset was used to estimate daily bed utilisation in each trust (our key explanatory variable for bed pressure). We also used publicly reported trust-level statistics on beds available overnight, bed occupancy rate and A&E staffing.

The HES A&E and APC datasets were merged at two levels:

- trust-level (based on the trust's 3-digits NHS code) to link dependent and explanatory variables; and

- episode-level (based on the anonymised patient identifier and date of arrival to A&E or admission to inpatient care).

Figure 1

Emergency care patient pathway: A&E performance and patient flow

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1   Comptroller and Auditor General, *Emergency admissions to hospital: managing the demand*, Session 2013-2014, HC 739, National Audit Office, October 2013 available here.
2   Quality Watch 2014, NHS Monitor 2015, Nuffield Trust 2016.

Methods

Data were extracted for attendances of A&E major departments (i.e. type 1) from 136 non-specialist acute trusts, from April 2015 to March 2016. The analysis was conducted on two populations: all A&E episodes (c. 15.5 million) and, using the episode-level merged data, A&E episodes followed by emergency admissions within the same trust (c. 3.5 million).

The 6 measures of A&E performance modelled as **dependent variables** were:

A&E performance indicators related to the 4-hour standard

- Time to departure (from the A&E department).

- Breaching the 4-hour standard.

- Departure after 3 hours and 50 minutes.[3]

Alternative A&E performance indicators

- Time to treatment (being assessed by a decision-making clinician).

- Patients leaving A&E department before treatment.

- 7-day A&E re-attendance for non-admitted patients.

Two **explanatory variables** were used to capture bed pressure:

- **Daily bed utilisation index** (number of admitted patients in a trust divided by the number of overnight beds): a proxy for daily pressure on beds within each trust. Index for the 366 days were categorized into quintiles of bed pressure.

- **Annual average bed occupancy rate:** based on the mean of NHS England's quarterly bed occupancy data, measuring the variation of average bed pressure between trusts.

A generalised linear model was fitted for continuous dependent variables and logistical regressions used for binary dependent variables. Standard errors were clustered at the trust-level to account for the hierarchical structure of the data.

Results

Within each trust, **high daily bed utilisation** was associated with poorer A&E performance against five of the six A&E performance measures. No association was found with 7-day A&E re-attendance for non-admitted patients ([Table 1](#)).

Comparing with the 1st quintile of bed utilisation (73 days of the year with lowest bed utilisation index), for any A&E episode occurring in a day of the 2nd, 3rd, 4th or 5th quintiles:

- time to departure increased by 1.7, 4.9, 10.1 and 14.4 minutes, respectively.[4]

- time to treatment increased 1.1, 1.9, 4.8 and 7.9 minutes, respectively.[5]

The **annual average bed occupancy rate** is associated with the performance against indicators related to the A&E 4-hour standard but not with the performance in alternative A&E domains (Table 1). A high annual average bed occupancy rate predicts a longer time to departure and increased odds of departing after 3 hours and 50 minutes, but does not increase odds of breaching the 4-hour standard.

The effect size (magnitude of coefficients) for A&E episodes resulting in admissions is higher than for all A&E episodes (see [Table 3](#) in the appendices).

Looking at associations between A&E performance and control variables we also found that:

- An increase in daily A&E attendances is associated with worse performance, except for 7-days re-attendance. A&E departments with low annual volume of activity have lower odds of breaching the target (compared to medium volume).

- A&E performance varies considerably depending on the time of the day, day of the week and season. Overall, performance worsens during the day. Compared with Wednesday, days with worse performance against the 4-hour standard related indicators are Monday and Tuesday, while performance in alternative measures is worse during weekends (see [Tables 2](#) and [3](#) in appendices).

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3   The rational for studying departure after 3h50m is the proportion of A&E episodes completed in the last 10 minutes of the 4-hour period.

4   For an episode with median time to departure of 166 minutes.
5   For an episode median time to treatment of 62 minutes.

Table 1

Regressions estimates: performance in all A&E episodes

	A&E 4h standard related			A&E alternative domains		
	Time to departure	Breach A&E standard	Departure A&E >3h50m	Time to treatment	Leaving before treatment	A&E re-attendance
	Coef	OR	OR	Coef	OR	OR
Daily bed utilisation index quintiles (ref 1st quintile)						
2nd quintile	0.010 *	1.118 **	1.080 **	0.018 *	1.050 *	1.003
3rd quintile	0.029 **	1.325 **	1.225 **	0.030 *	1.068 *	1.021*
4th quintile	0.059 **	1.685 **	1.434 **	0.074 **	1.130 **	1.023
5th quintile	0.083 **	1.797 **	1.538 **	0.120 **	1.187 **	1.013
Annual Average Bed Occupancy (ref <85%)						
85%–90%	0.024	1.013	1.198	-0.024	1.019	0.925
90%–95%	0.057 *	1.112	1.239 *	0.080	1.071	0.949
>95%	0.076 *	1.182	1.285 *	0.054	1.080	0.876*

Notes

1 For more detailed results see **Table 2** in the appendices.

2 For these tables "ref" is the reference category.

Conclusions

Bed pressure is associated with poor performance in A&E indicators related to the 4-hour standard, as well as alternative measures of A&E performance. The measure of daily variation in bed utilisation within each trust was more closely associated with performance and seems greater than that for annual average bed occupancy rate for each trust. There was no clear correlation between bed pressure and patient outcomes, as measured by A&E re-attendances. for patients that were not admitted.

The joint analysis of several domains of A&E performance is essential to capture a more complete picture than by examining solely the performance against the A&E 4-hour standard.

Limitations

The study identified associations and not causal effects. The main restriction to interpret bed pressure as a cause of worse A&E performance is the potential existence of confounding variables. There may also be measurement errors and coding inconsistencies, both for variables derived from HES and for the publicly reported data. The measurement of bed utilisation using HES inpatient data was exploratory and more work could be done to refine this variable.

References

NHS Monitor (2015). A&E delays: why did patients wait longer last winter? September 2015. Available **here**.

Nuffield Trust (2016). Understanding patient flow in hospitals. Briefing. Available **here**.

Quality Watch, 2014. Focus on: A&E attendances Why are patients waiting longer? The Health Foundation and Nuffield Trust. Available **here**.

We accessed bed availability and occupancy data from **here**. We accessed workforce statistics from **here**.

Appendix

Table 2
Regressions estimates: performance in all A&E episodes

	A&E 4h standard related			A&E alternative domains		
	Time to departure	Breach A&E standard	Departure A&E >3h50m	Time to treatment	Leaving before treatment	A&E re-attendance
	Coef	OR	OR	Coef	OR	OR
Daily bed utilisation index quintiles (ref 1st quintile)						
2nd quintile	0.010 *	1.118 **	1.080 **	0.018 *	1.050 *	1.003
3rd quintile	0.029 **	1.325 **	1.225 **	0.030 *	1.068 *	1.021*
4th quintile	0.059 **	1.685 **	1.434 **	0.074 **	1.130 **	1.023
5th quintile	0.083 **	1.797 **	1.538 **	0.120 **	1.187 **	1.013
Annual Average Bed Occupancy (ref <85%)						
85%–90%	0.024	1.013	1.198	-0.024	1.019	0.925
90%–95%	0.057 *	1.112	1.239 *	0.080	1.071	0.949
>95%	0.076 *	1.182	1.285 *	0.054	1.080	0.876*
Controls²						
Daily A&E attendances (ref 1st quintile)						
2nd quintile	0.036 **	1.196 **	1.150 **	0.084 **	1.145 **	0.999
3rd quintile	0.059 **	1.327 **	1.257 **	0.135 **	1.262 **	1.007
4th quintile	0.078 **	1.436 **	1.348 **	0.181 **	1.386 **	1.013
5th quintile	0.105 **	1.603 **	1.490 **	0.247 **	1.647 **	1.034**
Volume of A&E attendances (ref medium)						
Low	-0.030	0.697 *	0.858	-0.131	0.960	1.021
High	-0.002	0.964	0.984	0.016	1.093	1.042
Very High	0.002	0.935	1.017	0.009	1.060	1.154**
Hour of A&E episode (ref morning)						
Early Morning	-0.016 **	1.016	0.959 *	-0.088 **	0.954	1.167**
Afternoon	0.044 **	1.204 **	1.170 **	0.093 **	1.512 **	1.053**
Evening	0.095 **	1.419 **	1.424 **	0.264 **	2.169 **	1.161**
Night	0.179 **	1.828 **	1.812 **	0.410 **	3.441 **	1.438**
Overnight	0.181 **	2.041 **	1.785 **	0.332 **	3.433 **	1.431**
Day of A&E episode (ref Wednesday)						
Sunday	0.012 *	0.999	1.027	0.089 **	1.102 **	1.064**
Monday	0.012 **	1.115 **	1.040 *	0.008	0.980	0.974**
Tuesday	0.011 **	1.108 **	1.054 **	0.004	1.015	0.986*
Thursday	0.001	0.976 *	0.999	0.006	1.017	1.019**
Friday	-0.007 *	0.925 **	0.987	0.008	1.034 *	1.076
Saturday	0.008	0.962	1.026	0.087 **	1.145 **	1.115

Table 2 *continued*

Regressions estimates: performance in all A&E episodes

	A&E 4h standard related			A&E alternative domains		
	Time to departure	Breach A&E standard	Departure A&E >3h50m	Time to treatment	Leaving before treatment	A&E re-attendance
	Coef	OR	OR	Coef	OR	OR
Quarter of A&E episode (ref Apr–Jun)						
Jul–Sept	-0.030**	0.760**	0.849**	-0.035**	0.987	1.008
Oct–Dec	-0.002	0.910	0.935*	-0.008	1.000	0.994
Jan–Mar	0.043**	1.262**	1.128**	0.042*	1.067	1.002
No. observations	14457854	14457854	14457854	13100000	14641974	10446485
No. trusts (clusters)	136	136	136	136	136	136
Pseudo R2 (logistic regression)	n/a	0.162	0.185	n/a	0.072	0.014
Cross Validation Table (% correctly classified)	n/a	87.80%	79.14%	n/a	96.91%	89.97%
Pearson or Homer-Lemershow test (p-value)	n/a	1.000	0.002	n/a	0.000	0.000

Notes

1   * p-value<= 0.05; ** p-value<=0.01.

2   Results presented for selected control variables. Additionally, other control variables adjusted for include: A&E department conversion rate, ratio medical staff per A&E attendances, proportion of senior medical staff, NHS region of the trust, arrival mode to the A&E department, referral source of the A&E episode, outcome of the A&E episode, age, sex and deprivation of the patient (IMD-04).

Table 3

Regressions estimates: performance in A&E episodes resulting in hospital admission

	A&E 4h standard related			A&E alternative domains
	Time to departure	Breach A&E standard	Departure A&E >3h50m	Time to treatment
	Coef	OR	OR	Coef
Daily bed utilization index quintiles (ref 1st quintile)				
2nd quintile	0.021**	1.138**	1.104**	0.024**
3rd quintile	0.062**	1.425**	1.316**	0.051**
4th quintile	0.107**	1.812**	1.525**	0.100**
5th quintile	0.138**	2.025**	1.695**	0.158**
Annual Average Bed Occupancy (ref <85%)				
85%–90%	0.084*	1.190	1.383**	-0.026
90%–95%	0.069*	1.173	1.288*	0.082
>95%	0.059	1.154	1.190	0.052
Controls[2]				
Daily A&E attendances (ref 1st quintile)				
2nd quintile	0.031**	1.186**	1.145**	0.076**
3rd quintile	0.047**	1.301**	1.236**	0.125**
4th quintile	0.058**	1.378**	1.293**	0.165**
5th quintile	0.071**	1.498**	1.392**	0.226**
Volume of A&E attendances (ref medium)				
Low	-0.050	0.664*	0.828*	-0.060
High	0.014	1.034	0.988	0.058
Very High	0.029	1.076	1.149	0.035
Hour of A&E episode (ref morning)				
Early Morning	0.016*	1.001	0.929**	-0.039**
Afternoon	0.031**	1.188**	1.175**	0.095**
Evening	0.037**	1.204**	1.239**	0.259**
Night	0.061**	1.174**	1.183**	0.366**
Overnight	0.116**	1.412**	1.209**	0.312**
Day of A&E episode (ref Wednesday)				
Sunday	-0.013*	0.930**	0.943**	0.095**
Monday	0.034**	1.195**	1.089**	0.010
Tuesday	0.027**	1.157**	1.086**	0.010*
Thursday	-0.012**	0.947**	0.973**	0.005
Friday	-0.025**	0.887**	0.961**	0.020**
Saturday	-0.030**	0.859**	0.925**	0.095**

Table 3 *continued*

Regressions estimates: performance in A&E episodes resulting in hospital admission

	A&E 4h standard related			A&E alternative domains
	Time to departure	Breach A&E standard	Departure A&E >3h50m	Time to treatment
	Coef	OR	OR	Coef
Quarter of A&E episode (ref Apr–Jun)				
Jul–Sept	-0.057**	0.724**	0.823**	-0.039**
Oct–Dec	-0.029**	0.850*	0.886**	-0.025
Jan–Mar	0.026*	1.137	1.029	0.016
No. observations	3370363	3370363	3370363	3211972
No. trusts (clusters)	136	136	136	135
Pseudo R2 (logistic regression)	n/a	0.071	0.055	n/a
Cross Validation Table (correctly classified %)	n/a	73.00%	61.1%	n/a
Pearson or Homer-Lemershow test (p-value)	n/a	0.000	0.022	n/a

Notes

1   * p-value<= 0.05; ** p-value<=0.01.

2   Results presented for selected control variables. Additionally, other control variables adjusted for include: A&E department conversion rate, ratio medical staff per A&E attendances, proportion of senior medical staff, NHS region of the trust, arrival mode to the A&E department, refrral source of the A&E episode, age, sex and deprivation of the patient (IMD-04).