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Article *in* European Journal of Emergency Medicine · August 2011

DOI: 10.1097/MEJ.0b013e328344917e · Source: PubMed

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Increasing wait times predict increasing mortality for emergency medical admissions

Patrick K. Plunkett[a], Declan G. Byrne[b], Tomás Breslin[a], Kathleen Bennett[c] and Bernard Silke[b,c]

Background **The actual impact of emergency department (ED) 'wait' time on hospital mortality in patients admitted as a medical emergency has often been debated. We have evaluated the impact of such waits on 30-day mortality, for all medical patients over a 7-year period.**

Methods **All patients admitted as medical emergencies by the ED between 2002 and 2008 were studied; we looked at the impact of time to medical referral and subsequent time to a ward bed on any inhospital death within 30 days. Significant univariate predictors of outcome, including Charlson's comorbidity and acute illness severity score, were entered into a multivariate regression model, adjusting the univariate estimates of the readmission status on mortality.**

Results **We studied 23 114 consecutive acute medical admissions between 2002 and 2008. The triage category in the ED was highly predictive of subsequent 30-day mortality ranging from 4.8 (category 5) to 46.1% (category 1). After adjustment for all outcome predictors, including comorbidity and illness severity, both door-to-team and team-to-ward times were independent predictors of death within 30 days with respective odds ratios of 1.13 (95% confidence interval 1.07–1.18), and 1.07 (95% confidence interval 1.02–1.13).**

Conclusion **Delay to admission have been shown to be independently adversely related to mortality outcome. We recommend maximal target limits of 4 and 6 h for referrals and admissions, respectively, based on these mortality observations.** ***European Journal of Emergency Medicine*** **00:000–000 © 2011 Wolters Kluwer Health | Lippincott Williams & Wilkins.**

European Journal of Emergency Medicine 2011, **00**:000–000

Keywords: access block, acute medical admissions, emergency, 4-h target, hospital inpatient enquiry, mortality, outcome, triage, waits

[a]Department of Emergency Medicine, [b]Division of Internal Medicine and [c]Department of Pharmacology and Therapeutics, Trinity Centre for Health Sciences, St James's Hospital, Dublin, Ireland

Correspondence to Dr Patrick K. Plunkett, FRCSEd, FRCSGlas, FRCPI, FCEM, Department of Emergency Medicine, St James's Hospital, Dublin 8, Ireland
Tel: +353 1 416 2777; fax: +353 1 410 3451;
e-mail: patrick.plunkett@tcd.ie

Received 14 May 2010 **Accepted** 12 January 2011

Introduction

Over the past 2 decades, there has been increasing interest in the phenomenon of 'access block' within emergency departments (EDs) and its effect on patient processing, ambulance diversion and patient satisfaction [1–4]. Adverse outcome of 'access block' on patient processing time and on patient mortality has also recently been reported [5,6].

The National Health Service (NHS) plan 2000 [7] set a 4-h target to ensure that no patient should spend more than 4 h in an ED from arrival to admission and transfer or discharge in England (note that this did not apply to Ireland). Although this led to increased patient satisfaction, the 4-h target (of achieving an escalating target of towards 98% admissions/discharges from the ED) was introduced for political reasons, rather than based on the analysis of needs. As far as we are aware, no in-depth analysis of its effect on the outcome has been attempted. Furthermore, there have been suggestions of hastening admissions merely to avoid breaching the targets [8], which it has been suggested, might be obviated by somewhat longer target times, or lower target percentages. Of note, at this point the NHS have moved away from the 4-h target, towards a system of quality indicators, much to the chagrin of the Society of Acute Medicine [9].

We introduced a centralized Acute Medical Admission Unit (AMAU) in 2005 to attempt to streamline inpatient flow for the bulk of emergency admissions, which in our institution, fell under the general internal medicine umbrella. We noted a subsequent improvement in lengths of inpatient stay and in overall mortality figures [10,11].

Given the continuing difficulties with boarded inpatients causing access block in Irish EDs, described in March 2006 by the Minister of Health and Children, Mary Harney, as a 'national emergency' [12], the Emergency Department Task Force was set up by the health service executive. This set an empirical target for 6 h as maximal time for any patient to remain in the ED, whether they were being admitted or discharged [13]. Just as in the NHS plan 2000, this target time was based on opinion, rather than research.

We decided to evaluate our experience before achieving the 6-h target, to see if there was any scientific basis for accepting this target time.

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Methods

Background

St James's hospital, in addition to national and regional roles, serves as a secondary care centre for emergency attendances for its local Dublin catchment area of 270 000 adults. Patients, once stabilized and assigned a working diagnosis requiring admission by the emergency physicians are referred to surgical or medical specialties. This study deals solely with patients admitted under the general medical service.

Emergency medical patients are admitted from the ED to an AMAU; its 59-bed capacity is such that up to 70% of all admissions could be predicted to receive their entire hospital care within the maximum permitted stay of 5 days in AMAU. The AMAU is geographically located at the heart of the hospital, proximate to both the ED, and the department of diagnostic imaging, beneath the ICU and high dependency units on the floor above. Priority is given to AMAU patients for access to inpatient diagnostic procedures, imaging and specialist consultations, whereas these have not already been performed in the ED. The operation and outcome of the AMAU to 2007 has been described elsewhere [9]. No patients less than 14 years of age are seen in the ED.

Data collection

A dedicated patient database was created to link the computerized patient administration system to the hospital inpatient enquiry (HIPE) scheme. HIPE is a national database of coded discharge summaries from acute public hospitals in Ireland, run by the Economic and Social Research Institute (*http://www.esri.ie/health_information/hipe*). Ireland used the International Classification of Diseases, ninth revision, Clinical Modification (ICD-9-CM) for both diagnosis and procedure coding from 1990 to 2005, and has used International Classification of Diseases, tenth revision, Clinical Modification since then.

Linking the HIPE dataset with the patient administration system, dataset permits interrogation of routinely collected data for the purposes of research, planning and quality control. Data collected includes unique hospital number, name of the patient, admitting consultant, date of birth, sex, area of residence by county, principal diagnosis, up to nine additional secondary diagnoses, procedures (principal and up to nine additional secondary procedures) and admission and discharge dates. Additional information crosslinked and automatically uploaded to the database includes physiological, haematological and biochemical datasets relating to the emergency attendance generating the admission.

The HIPE dataset of all coded diseases at the time of discharge/death, together with procedures and investigations undertaken during the hospital stay, was examined. Data were related to all emergency general medical patients admitted to St James's hospital between 1 January 2002 and 31 December 2008. Additional time parameters crosslinked included the time of presentation to the ED ('door' time), the time referred from emergency medicine to the admitting medical service ('team' time) and the time admitted to a hospital bed ('ward' time). Triage categories, based on the Manchester Triage System [14] were category 1 (resuscitation), 2 (very urgent), 3 (urgent), 4 (standard) and 5 (nonemergency).

Derangement of haemodynamic and physiological admission parameters may be used to predict the clinical outcome. We have previously derived and applied an acute illness severity score (AISS) [15], for predicting inhospital mortality from the following seven parameters routinely recorded in the ED: age and basic laboratory tests (i.e. serum sodium, serum potassium, serum urea, serum albumin, red cell distribution width and white blood cell count). As described earlier, significant predictors from the univariate analyses above were entered into a multivariable logistic regression model, using fractional polynomials for all continuous measures (except age), to examine nonlinear associations. The method proposed by Saurbrei *et al.* [16] was applied, as a systematic approach to investigate possible nonlinear functional relationships based on fractional polynomials and the combination of linear and nonlinear predictor variables with backward elimination. The original model was derived in 15 935 patients between 2002 and 2006 with an area under the receiver operating characteristic (AUROC) curve to predict a death at 30 days of 0.84 [95% confidence intervals (CI) 0.83–0.85] and validated in 7392 patients from 2007 to 2008 with a receiver operating characteristic of 0.85 (0.84–0.86). More than one missing data element prevents calculation of AISS.

Statistical methods

Descriptive statistics were calculated for background demographic data, including means/standard deviations, medians/interquartile ranges (IQRs) or percentages. Comparisons between categorical variables and mortality were made using χ^2-tests. We divided 'wait' times into five quantiles, based on the 10th, 25th, 75th and 90th centiles of the frequency distribution. Logistic regression analysis was used to examine the univariate risk of a mortality on 30-day hospital mortality; this risk estimate was then adjusted for sex, major disease by category, Charlson's comorbidity index, ICU admission, blood transfusion, troponin elevation, door-to-team and team-to-ward time. Finally, the 30-day risk estimate was adjusted for AISS. Odds ratios and 95% CI were calculated whenever appropriate. Statistical significance at a P value of less than 0.05 was assumed throughout the study. JMP v.7 statistical software (SAS Institute Inc., North Carolina, USA) was used for analysis.

Results

Patients

A total of 38 894 episodes were recorded among 23 114 patients admitted acutely by ED between 1 January 2002 and 31 December 2008. The episodes recorded represented all medical admissions during the observation period, including patients admitted to the ICU and high dependency unit. The patients' sex, their median age and length of stay (LOS) are shown in the Table 1.

The median (IQR) LOS was 4.6 (1.8–9.2) days. The median (IQR) age was 58.3 (37.6–75.4) years, with the upper 10% boundary at 83.6. The proportion of males was 48.2%. The major disease categories were respiratory (22.0%), cardiovascular (16.7%), neurological (17.4%) and gastrointestinal (11.5%).

Mortality and triage category

The proportion of patients in triage categories 1–5 were 1.8, 33.8, 62.2, 1.6 and 0.6%, respectively; mortality for each category showed a highly significant overall increase ($P < 0.0001$) with respective 30-day mortality rates of 46.1, 12.9, 5.7, 3.3 and 4.8%. The unit odds rate for a 30-day death (unadjusted) was 2.84 (95% CI 2.61–3.08). When adjusted for other mortality predictors, including AISS, it was 1.53 (95% CI 1.35–1.73), that is a 53% increase for each triage category from 5 to 1.

Door-to-team time

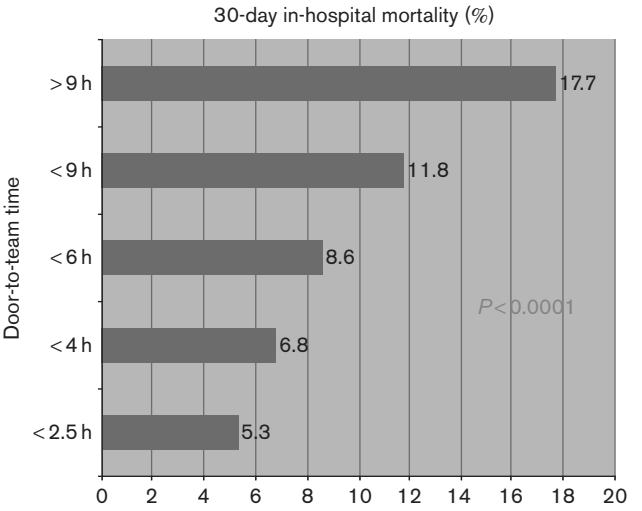
The 10th, 25th, 50th and 75th centiles of this distribution fell at 2.6, 3.9, 5.8 (median) and 8.7 h; we used these cutoffs (rounded to the closest ½ h) to define five risk categories. Overall mortality at 30 days (Fig. 1) increased from 5.3% (< 2.5 h) to 6.8, 8.6, 11.8 and 17.7% (for those more than 9 h; $P < 0.0001$). The door-to-team time was an independent predictor of 30-day mortality after adjustment for all major predictors, excluding AISS, at 1.14 (95% CI 1.08–1.2). When AISS was added to the model, the risk fell to 1.13 (95% CI 1.07–1.18). As mentioned earlier, this score cannot be calculated for a cohort if more than one variable is missing from the underlying data (14% had some missing data).

Table 1 Details of emergency medical admissions (2002–2008)

Variable	
Sex	
Male	11 130 (48.2%)
Female	11 984 (51.8%)
Total	23 114 (100%)
Age (years)	
Median (IQ range)	58.3 (37.6–75.4)
Length of stay (days)	
Median (IQ range)	4.6 (1.8–9.2)
Charlson's comorbidity index	
>0	41.2%
>1	17.1%
Readmissions	
None	16843=72.9%
One	3465=15.0%
Two	1241=5.4%
Three	621=2.7%
Four	328=1.4%
Five or more	616=2.7%

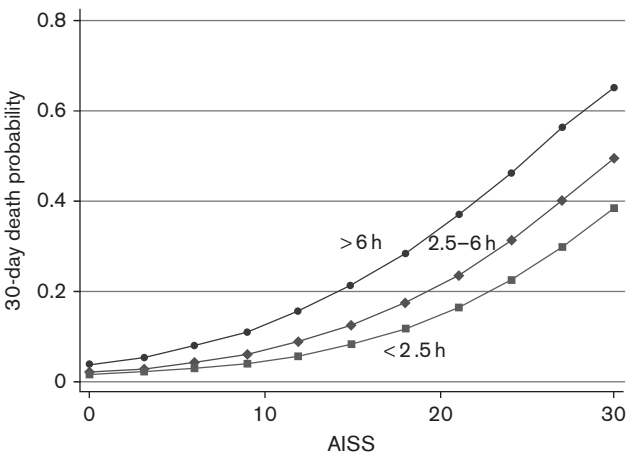
IQ range, interquartile range.

Fig. 1



Mortality related to door-to-team quantiles.

Fig. 2



Predicted probabilities derived from the regression equation of a death plotted against the acute illness severity score. AISS, acute illness severity score.

The logistic regression model predicting mortality at 30 days, when graphed against the AISS at time of initial examination, showed clear delineation between those with wait times of less than 2.5, 2.5–6 and more than 6 h (Fig. 2).

Team-to-ward time

The 10th, 25th, 50th and 75th centiles of this distribution fell at 0.97, 2.6, 6.2 (median) and 14.3 h; we used

Table 2 Predictors of an in-hospital death at 30 days

Parameter	OR (95% CI)	*P*<
ICU admission	9.04 (7.31–11.2)	0.0001
Troponin +	3.74 (3.13–4.47)	0.0001
MDC 1 (nervous)	2.57 (2.07–3.18)	0.0001
Acute illness severity	1.81 (1.74–1.88)	0.0001
MDC 4 (respiratory)	1.70 (1.44–2.01)	0.0001
MDC 5 (circulatory)	1.65 (1.36–2.0)	0.0001
Triage category	1.49 (1.32–1.68)	0.0001
Door-to-team time	1.13 (1.07–1.19)	0.0001
Team-to-ward time	1.07 (1.02–1.13)	0.01

CI, confidence interval; MDC, major disease by category; OR, odds ratio.

these cutoffs (rounded to 1, 2.5, 6 and 14 h) to define five risk categories. Mortality at 30 days increased from 5.1% (< 1 h) to 8.7, 11.1, 11.6 and 14.8%, respectively. ($P < 0.0001$.) The team-to-ward time was an independent predictor of 30-day mortality after adjustment for all major predictors, excluding AISS at 1.17 (95% CI 1.12–1.22). Adjustment for AISS did not significantly alter the predictive ability of this time parameter at 1.07 (95% CI 1.02–1.13).

Full model analysis

Table 2 presents data from a logistic regression model; this examines the modification of the univariate risk when other significant predictors (covariates) of 30 days mortality are included in the model. Effectively, the extent to which the univariate risk, a composite, will be adjusted downwards by other predictors is investigated.

The adjusted odds ratio for both the door-to-team and the team-to-ward times indicated each independently predicted 30-day outcome.

The former with an adjusted χ^2 of 18.5, versus 7.9 for the latter, suggested an effect size that was different. The OR for the door-to-team time at 1.13 (95% CI, 1.07–1.19) appeared larger than the effect of delays in time to access a ward bed at 1.07 (95% CI, 1.02–1.13).

Survivalship prediction

On the basis of the mortality data shown, we would propose that time to a medical referral should not exceed 4 h and total time to a bed 6 h. Given the number needed to treat from our earlier study [11], we would predict that approximately 100 additional lives could be saved per annum by remaining within this 6-h limit.

Discussion

The burden of access block on EDs is now well documented in multiple systems worldwide. It is clear that EDs are used as throttle points in the access to healthcare, to smooth out peaks of demand and troughs of supply. There is logic to this approach, but at times it seems to be uncontrolled. Although uncomfortable for patients and staff, leading to reduced satisfaction, to date there has been little proof that access block leads to poor outcomes [5,6]. Richardson [17], reporting from a similar sized department in Canberra, showed a link between overcrowding and 10-day in-hospital mortality equivalent to 13 extra deaths per annum.

When realigning our hospital processes, to include an AMAU, we showed earlier an improvement in both average LOS and in mortality for emergency medical admissions.

Anecdotally, when our hospital has few long-stay, high-dependency patients, who have recovered from their acute medical illness, but are awaiting placement in nursing home beds, the ED does not suffer access block. This has been of variable impact over the past 10 years. It has been shown by Cunningham *et al.* [18] at the Mercer's Institute for Research in Ageing, that the survival of such patients is predictable, so a steady state demand for such patient care can be calculated and provided for, thus potentially reducing access block and consequent overcrowding.

When there is no access block, our experience is that times to acute medical care diminish, with transfer to the ward beds facilitated within 1 h of decision to admit by the emergency medicine team. Once access block occurs, the patients remain in the ED, with the admitting medical team having to straddle between the wards and the ED. Furthermore, there is a relative decrease in the available clinical space with consequent potential inefficiency for both emergency physicians and admitting medical teams.

This analysis shows how there is a statistically significant deterioration in the outcome, with an increased 30-day mortality, once patient processing time in the ED moves beyond 4 h for the emergency medicine staff and a further 2 h for the internal medicine staff. As said earlier, aiming to keep time to a medical referral for less than 4 h and maximal time to a bed for less than 6 h could save 100 additional lives per annum.

Although there may be multiple factors involved, it is clear that this trend crosses the entire spectrum of patients from the most critically ill to those who would have been assumed to be at minimal risk of death.

Another item of importance to emergency physicians is the finding that mortality was linked clearly to the initial triage category assigned, with a stepwise increase of more than 50% per triage grouping from the least acute to those needing immediate resuscitation. This is of interest as triage is a tool designed for measuring the degree of urgency of illness, rather than its severity.

Although the 6-h target was originally aimed to be in place by February 2009, and is a 100% performance target of the health service executive for 2010, it had not been implemented by the time this study had been submitted for publication.

This is the first published scientific underpinning of a specific maximal time target for ED processing. We hope our contribution to the debate will lead to an improvement in both process and outcome for our patients.

Limitations

This single centre retrospective study focuses on ED admissions for medical emergencies, which constitute more than 65% of all our emergency admissions. Acute coronary syndrome and cardiac dysrhythmias are admitted to the cardiology service, rather than AMAU, and were excluded from our study, as they were orthopaedic and surgical cases.

The specific causes for delays in referral ('door to team') and to formal admission ('team to ward') have not been analysed further in regard to whether cases were more or less complex, as the adverse outcomes for increasing time were shown to be independent of the case morbidity indices. Neither have we attempted in this study to link delay directly to the level of overcrowding, nor 'access block', as there is still a lack of agreement on the definition of 'access block' and methods to measure it.

Acknowledgement

None of the authors have any conflict of interest to declare.

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