

Mortality outcomes and emergency department wait times - the paradox in the capacity limited system

D Byrne, JG Browne, R Conway, S Cournane, D O'Riordan & B Silke

Abstract

Background: There is concern that undue ED wait times may result in adverse outcomes.

Methods: We studied 30-day in-hospital mortality (2002-2017) for all medical admissions (106,586 episodes; 54,928 patients) focusing on clinical risk profile

Results: Comparing 2002-09 vs. 2010-17, median ED waits > 6 hours (hr) increased 10h (95% CI: 8,13) to 15h (95% CI: 9,19). 30-day mortality declined 6.2% to 4.9% (RRR- 20.8%/ NNT- 78). 30-day-mortality by ED wait: < 4hr 6.6% (95% CI: 6.3%, 6.9%), 4-8hr 4.8% (95% CI: 4.6%, 5.0%), 8-12hr 4.3% (95% CI: 4.1%, 4.5%) or ≥12hr 4.2% (95% CI: 3.9%, 4.5%).

Conclusion: Admissions with shorter waits are overrepresented with high clinical acuity. Higher Risk Score patient with extended wait times had worse clinical outcomes.

Keywords

Emergency Department, Wait Times, Acute Illness Severity, Manchester Triage Category.

Introduction

The discipline of Acute Medicine investigates and treats urgent clinical conditions that require immediate and specialist management.¹ The immediate outcomes of an emergency medical admission appear to have improved over time;² the restructuring of operational systems^{3,4} and the establishment of acute medical admissions units (AMAU)^{5,6} have contributed to an improvement in clinical outcomes. The USA National Hospital Discharge Survey (NHDS) data from 2000 through 2010 reported that inpatient hospital deaths decreased 8% from 2000 to 2010⁷ – an effect size comparable with the outcome improvement we have witnessed.

We must remain cognizant of these data when concerns are expressed about Emergency Department (ED) waiting times. We previously reported that longer Emergency Department waiting times were associated with worse 30-day hospital outcomes.⁸ The evidence of the relationship between ED waiting times has focused on high acuity patients – where delays in time sensitive treatments for serious conditions might impact on outcomes.⁹ Emergency Department wait times have been correlated with an increased risk of death and subsequent hospital admission in patients initially evaluated and discharged from the ED.⁹ Of course there are resource constraints to population health care funding and in this paper we focus on a paradox – improving clinical outcomes at a time of deterioration in acute hospital capacity with increasing wait time across the acute hospital system. Ireland has 3.1 acute hospital beds/ 1000 of the population versus a European average of 5.3/1000; for a population of

4.7 million, this implies an approximate 10,000 acute bed capacity deficit. An Irish Department of Health strategy document (the Codd report) recognised the immediate need in 2002 for 1500 new beds with 6000 further beds before 2006.¹⁰ At that time, 23 hospitals were found to have occupancy levels of greater than the functionally ideal rate of 85% with an average occupancy level of 95%. However, the collapse of the Irish economy resulted in serious austerity with health service spending especially targeted with reduced absolute spend over nearly a decade. Such parsimony was likely to have consequence and demographic trends and increased demand have created a capacity problem with year on year increases in ED wait numbers across the state. Clearly risk management then results in the sickest patients receiving priority for immediate access to beds – this raises the possibility that shorter wait times would be over represented with seriously ill patients who would have worse outcomes.

We therefore have investigated the relationship between ED wait times and clinical outcomes (30-day hospital episode mortality) for emergency medical admissions (>105,000) between the years 2002-2017. We look at the interaction between clinical acuity as measured by the Manchester Triage system¹¹ and the clinical Risk Score¹² of each admission.

Methods

Background

St James's Hospital, Dublin serves as a secondary care centre for emergency admissions in a catchment area with a population of 270,000 adults. All emergency

Declan Byrne¹
MB MSc FRCPI

Joseph G Browne¹
MD MRCPI

Richard Conway¹
MD MRCPI

Seán Cournane²
PhD

Deirdre O'Riordan¹
MD FRCPI

Bernard Silke¹
MD DSc FRCPI

¹ Department of Internal Medicine

² Medical Physics and Bioengineering Department, St James's Hospital, Dublin 8, Ireland.

Correspondence

Declan Byrne
Department of Internal Medicine, St James's Hospital, Dublin 8, Ireland
Email: debyrne@stjames.ie

Mortality outcomes and emergency department wait times - the paradox in the capacity limited system

medical admissions were admitted from the ED to an Acute Medical Admission Unit, the operation and outcome of which have been described elsewhere.^{2,5} As a city centre hospital St James's admits persons resident elsewhere but working in the capital in addition to visitors to Dublin who became acutely ill. The number of emergency medical admissions resident in the catchment area was 74.5%; this compares with a figure of 59% for ED presentations where the social influences on emergency department visitations on two London hospitals have been examined.¹³

Data collection

An anonymous patient database was employed, collating core information of clinical episodes from the Patient Administration System (PAS), the national hospital in-patient enquiry (HIPE) scheme, the patient electronic record, the emergency room and laboratory systems. HIPE is a national database of coded discharge summaries from acute public hospitals in Ireland.^{14,15} International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) has been used for both diagnosis and procedure coding from 1990 to 2005 with ICD-10-CM used since then. Data included parameters such as the unique hospital number, admitting consultant, date of birth, gender, area of residence, principal and up to nine additional secondary diagnoses, principal and up to nine additional secondary procedures, and admission and discharge dates. Additional information cross-linked and automatically uploaded to the database includes physiological, haematological and biochemical parameters.

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 System¹¹ were category 1 (immediate), 2 (very urgent), 3 (urgent), 4 (standard) and 5 (non-emergency). In this paper wait time is defined as time from ED presentation to admission to a hospital bed.

Acute Illness Severity Score:

Derangement of biochemical parameters may be utilised to predict clinical outcome. We derived an Acute Illness Score based on laboratory data – this is an age adjusted 30-day in-hospital mortality risk estimator, representing an aggregate laboratory score based on the admission serum sodium (Na), serum potassium (K), serum urea, red cell distribution width (RDW), white blood cell count (WCC), serum albumin and troponin values at admission and applied as an Acute Illness Severity

score;^{16,17} the score predicts 30-day in-hospital mortality from the biochemical parameters recorded in the Emergency Department.¹⁸ The Illness Severity score can be enhanced with data from the ICD9/10 discharge codes to compute Co-Morbidity (as per the Charlson Index¹⁹) and chronic disabling disease²⁰ status. This Risk Score is exponentially related to the 30-day episode mortality outcome with a range of model adjusted mortality outcomes from 2.5% (2.3%–2.6%) to 32.1% (30.4%–33.8%). We have demonstrated using a nomogram that this laboratory models derives most of its predictive power from the values of albumin, urea and haemoglobin recorded at the time of admission.²¹

Statistical methods

Descriptive statistics were calculated for background demographic data, including means/standard deviations (SD), medians/inter-quartile ranges (IQR), or percentages. Comparisons between categorical variables and mortality were made using chi-square tests.

We employed a logistic model with robust estimate to allow for repeated admissions; the correlation matrix thereby reflected the average dependence among the specified correlated observations.¹⁶ Logistic regression analysis identified potential mortality predictors and then tested those that proved to be significant univariate predictors ($p < 0.1$ by Wald test). We used the margins command in Stata 13.1 to estimate and interpret adjusted predictions for subgroups, while controlling for other variables such as time, using computations of average marginal effects. Margins are statistics calculated from predictions of a previously fitted model at fixed values of some covariates and averaging or otherwise over the remaining covariates. In the multiple variable model (logistic), we adjusted univariate estimates of effect, using the previously described outcome predictor variables. The model parameters were stored; post-estimation intra-model and cross-model hypotheses could thereby be tested.

Adjusted odds ratios (OR) and 95% confidence intervals (CI) were calculated for those predictors that significantly entered the model ($p < 0.10$). Statistical significance at $P < 0.05$ was assumed throughout. Stata v.15 (Stata Corporation, College Station, Texas) statistical software was used for analysis.

Results

Patient Demographics

Over the 16-year study period (2002–2017), there were a total of 106,586 episodes of medical emergencies in 54,928 unique patients admitted through the Emergency Department. These

Mortality outcomes and emergency department wait times - the paradox in the capacity limited system

Table 1. Characteristics of Emergency Medical Admission Episodes by ED wait time

	<6 hr	(N = 57511)	p-value
	>= 6 hr	(N = 49277)	
Age (yr.)			
Mean (SD)	61.52 (20.72)	61.32 (20.59)	0.120
Median (Q1, Q3)	65.4 (44.9, 79.1)	65.1 (44.8, 78.8)	
Length Stay (day)			
Mean (SD)	13.70 (32.82)	15.78 (37.17)	<0.001
Median (Q1, Q3)	5.2 (1.9, 12.1)	6.6 (3.0, 13.8)	
Gender			
Male	27929 (48.7%)	23965 (48.7%)	0.956
Female	29416 (51.3%)	25258 (51.3%)	
30-day Hospital Mortality			
Alive	53886 (94.0%)	46867 (95.2%)	<0.001
Dead	3459 (6.0%)	2356 (4.8%)	
Triage			
1	191 (0.4%)	124 (0.3%)	<0.001
2	857 (1.7%)	658 (1.4%)	
3	24753 (47.9%)	23464 (49.9%)	
4	24496 (47.4%)	22123 (47.1%)	
5	1331 (2.6%)	628 (1.3%)	
Illness Severity			
1	1542 (3.0%)	1426 (3.1%)	0.190
2	3433 (6.7%)	3165 (6.9%)	
3	5844 (11.3%)	5273 (11.5%)	
4	8040 (15.6%)	7204 (15.7%)	
5	9980 (19.3%)	8656 (18.9%)	
6	22740 (44.1%)	20082 (43.8%)	
Chalson Index			
0	26071 (45.5%)	21018 (42.8%)	<0.001
1	14917 (26.0%)	13934 (28.4%)	
2	16283 (28.4%)	14138 (28.8%)	
Disabling Group			
0	6452 (11.3%)	4281 (8.7%)	<0.001
1	13313 (23.2%)	10824 (22.0%)	
2	16405 (28.6%)	13946 (28.3%)	
3	12512 (21.8%)	11611 (23.6%)	
4	8663 (15.1%)	8561 (17.4%)	
Sepsis Group			
1	43002 (75.0%)	35731 (72.6%)	<0.001
2	11781 (20.5%)	11285 (22.9%)	
3	2562 (4.5%)	2207 (4.5%)	

LOS: length of stay, IQR: Inter-Quartile Range

episodes represented all emergency medical admissions, including patients admitted directly into the Intensive Care Unit or High Dependency Unit, respectively. The proportion of males was 48.5%. The median (IQR) length of stay (LOS) was 4.3 days (1.7, 8.9). The median (IQR) age was 58.9 yr. (38.2, 76.3) with the upper 10% boundary at 85.0 yr.

The demographic characteristics (Table 1) are outlined with a cut point at the 6 hr wait time and tabulated (to allow group comparisons) by Acute Illness Severity.^{16,17} Charlson Co-Morbidity Index,¹⁹ Chronic Disabling Disease Score²⁰ and Sepsis status.²² One might put forward the hypothesis that prioritization of urgent cases in a capacity constrained system resulted in those with a shorter wait time having a worse 30-day episode mortality outcome - < 6 hr 6.0% vs. >= 6 hr 4.8%. However, there was little to distinguish between patients, related to wait times, in terms of Manchester Triage category, Acute Illness Severity, Charlson CoMorbidity, Chronic Disabling Disease or Sepsis Status. Patients with longer waits, >= 6 hr, had significantly longer hospital stays, 6.6 days (3.0, 13.8), compared to those with shorter ED wait times, 5.2 days (1.9, 12.1).

Mortality related Emergency Department wait times (Fig 1)

The median ED waits > 6 hr increased by approximately 50% from 10 hr (95% CI: 8,13) between 2002-09 to 15 hr (95% CI: 9,19) between 2010-17. The variability of this estimate also increased from SD 10.7hr between 2002-09 to 14.2

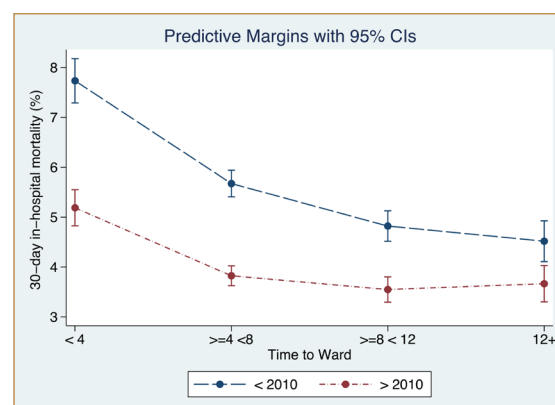


Figure 1. The relationship between the Emergency Department wait times and the 30-day in hospital mortality. Capacity constraints result in higher risk patients being prioritised for admission to an acute hospital bed. Thus paradoxically mortality outcomes are higher for those with the shortest waiting times. Short ED waits (< 4 hr) had a higher 30-day mortality 6.3% (95% CI: 6.0%, 6.6%) compared with those with longer ED wait times 4.5% (95% CI: 4.2%, 4.7%). Mortality outcomes improved over time unrelated to ED wait times (2002-09 versus 2010-17).

Mortality outcomes and emergency department wait times - the paradox in the capacity limited system

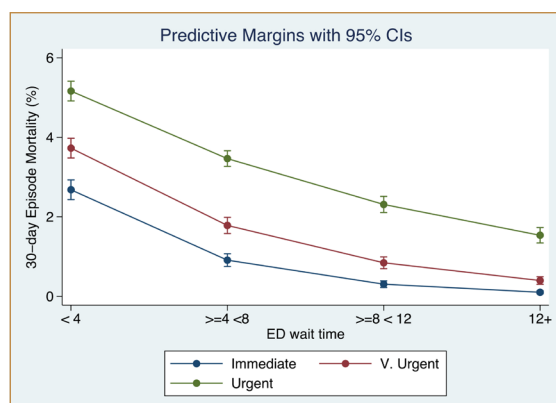


Figure 2. The relationship between the Emergency Department wait times for Manchester Triage Categories and subsequent 30-day in hospital mortality. Capacity constraints result in higher risk patients being prioritised for admission to an acute hospital bed. Those with the shortest waiting times (< 4 hr) had a higher 30-day mortality – e.g. Immediate 5.2% (95% CI: 4.9%, 5.4%) compared with those with longer ED wait times 2.5% (95% CI: 2.3%, 2.7%).

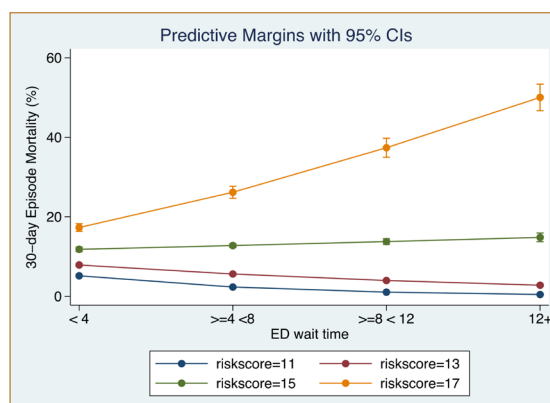


Figure 3. The relationship between the Emergency Department wait times for Risk Score and subsequent 30-day in hospital mortality. Higher Risk Scores over 11 points result in exponential increase in mortality risk. High Risk Score patients not prioritised for an early ward admission had worse outcomes. The model predicted 30-day mortality for risk scores > 15 increased from 16.3% (95% CI: 15.4%, 17.2%) to 37.5% (95% CI: 35.0%, 40.0%).

hr between 2010–17; that is, the likelihood of longer waits was greatly increased over time. However, the 30-day episode mortality declined between 2002 and 2017 – from 6.2% to 4.9%. This represented a relative risk reduction (RRR) on average over time of 20.8% with a numbers to treat (NNT) of 78. Considering the first and last year, the episode mortality figures were even more impressive – a mortality decline from 7.0% in 2002 to 4.5% in 2017. This represented a relative risk reduction (RRR) on average over time of 36.7% with a number needed to treat (NNT) of 39.

Short ED waits (< 4 hr – Fig 1) had a higher 30-day episode mortality compared with those with longer ED wait times – < 4 hr 6.6% (95% CI: 6.3%, 6.9%), >= 4 < 8 hr 4.8% (95% CI: 4.6%, 5.0%), >= 8 < 12hr 4.3% (95% CI: 4.1%, 4.5%) or >=12 hr 4.2% (95% CI: 3.9%, 4.5%). The progressive reduction in mortality over the last three wait time intervals were all significantly different (One-way with Scheffe's multiple comparison).

Interaction of Manchester Triage Category or Risk Score (Figs 2 and 3)

We considered the interaction between Emergency Department wait times and the categorisation of urgency as defined by the Manchester Triage System¹¹ with focus on the grades of 1 (immediate), 2 (very urgent) and 3 (urgent). The model suggested a highly significant interaction ($p < 0.001$) between the delay group and the Manchester Triage category – adjusted OR 1.41 (95% CI: 1.36, 1.45). Longer wait times in the Emergency Department were associated with progressive improvements in 30-day episode

mortality outcomes. For the immediate category 1, the mortality decline with longer wait times was as follows: < 4 hr 5.2% (95% CI: 4.9%, 5.4%), >= 4 < 8 hr 3.5% (95% CI: 3.3%, 3.7%), >= 8 < 12hr 2.3% (95% CI: 2.1%, 2.5%) or >=12 hr 1.5% (95% CI: 1.3%, 1.7%). For the very urgent category 2, the mortality decline with longer wait times was as follows: < 4 hr 3.7% (95% CI: 3.5%, 4.0%), >= 4 < 8 hr 1.8% (95% CI: 1.6%, 2.0%), >= 8 < 12hr 0.8% (95% CI: 0.7%, 1.0%) or >=12 hr 0.4% (95% CI: 0.3%, 0.5%).

The Risk Score is derived by summing the patient category of Acute Illness Severity score,^{16,17} the Charlson Index,¹⁹ the Chronic Disabling Disease²⁰ status and the Sepsis Status – their possible respective scores are 1–6, 1–3, 1–5 and 1–3 giving a maximal possible score of 17 points (range 4–17). The median Risk Score was 12 points (95% CI: 9, 14). This Risk Score is related to the 30-day episode mortality outcome with a range of mortality outcomes from 2.5% (2.3%–2.6%) to 32.1% (30.4%–33.8%) – the relationship to 30-day mortality outcomes increases exponentially with scores > 11 points. Patients with a high risk score who remained for a prolonged period in the Emergency Department had a considerably worse outcome (Fig 3). For those with a Risk Score of 15+ points, the mortality increased with longer wait times as follows: < 4 hr 16.3% (95% CI: 15.4%, 17.2%), >= 4 < 8 hr 22.1% (95% CI: 21.0%, 23.2%), >= 8 < 12hr 29.3% (95% CI: 27.6%, 31.0%) or >=12 hr 37.5% (95% CI: 35.0%, 40.0%). However, for those with a lower Risk Score, as exemplified by 13 points, the mortality declined with longer wait times as follows: < 4 hr 8.3% (95% CI: 7.9%, 8.7%), >=

Mortality outcomes and emergency department wait times - the paradox in the capacity limited system

4 < 8 hr 5.8% (95% CI: 5.5%, 6.0%), ≥ 8 < 12hr 4.0% (95% CI: 3.7%, 4.2%) or ≥ 12 hr 2.7% (95% CI: 2.4%, 3.0%).

Discussion

Recent years have witnessed increasing demand on healthcare services coupled with spiralling general healthcare costs. This has prompted investigations towards identifying greater healthcare efficiencies.^{23,24} As a result, clinical services have come under increased focus with the aim of providing greater effectiveness and ultimately reducing costs.²⁵

Different factors drive this demand – an ageing population (life expectancy increasing by 4.0 and 2.6 years for males and females respectively between 1970–2010) is now living longer with chronic ‘disabling’ conditions (9.2 and 9.4 years for males and females respectively in the same time period).²⁶ Our hospital catchment area is largely inner city with a high deprivation population²⁷ – the annual emergency admission rate incidence can vary eightfold from 5/1000 to 40/1000^{28–31} across the quintiles of deprivation. Where there are many dependents (i.e. proportions of young <15 years and older person ≥65 years) within such areas the annual admission rates can rise further to 60–80/1000.^{29,30} These factors were undoubtedly aggravated by an economic collapse that seriously restricted healthcare options following the demise of the Celtic Tiger. But ultimately all healthcare systems will struggle to support the demographic burden of a shift towards more dependants supported by fewer taxpayers. This paper looks at the pragmatic decisions of clinical practitioners when the emergency room is at capacity and there are few available acute beds to accommodate patients with a high acuity.

The data showed median wait times > 6 hr that have increased over the period by 50%. Irrespective, clinical outcomes have continued to improve. On average considering two 8 year intervals (2002–09 and 2010–17), the 30-day episode mortality declined from 6.2% to 4.9%. This represented a relative risk reduction (RRR), on average, over time of 20.8% with a numbers to treat (NNT) of 78. However, sicker patients appeared to have been prioritized whilst in the Emergency Department for clinical access to limited acute hospital beds. It is worth noting that there was no systematic hospital policy to operate according to an agreed protocol. However, it is a reasonable inference from the observation of an interaction between the Manchester Triage category¹¹ recorded at time of initial assessment in the Emergency Department; a model adjusted Odds Ratio of 1.41 (higher triage having shorter wait durations) clearly did not occur by chance. High Acuity patients were therefore over represented in the fraction of those admitted

to a ward bed within 4 hr. Patients who waited longer had a considerably lower 30-day mortality outcome for all three most critical Manchester Triage categories. While the latter categorical information was available in real time during the admission and ‘trolley’ periods, the Risk Score was not. This was derived post-hoc, from a combination of laboratory data^{16,22} and clinical (hospital discharge) coding.^{19,20,32} Importantly however, the clinical Risk Score identified a subgroup of High Risk patients whose outcome progressively deteriorated during an extended wait period in the Emergency period. More investigation of these patients is warranted but it is not immediately apparent that such adverse outcomes were a consequence of a general system overload. The total numbers waiting > 6 hr during each 24 hr period did not appear to influence outcomes in a similar fashion. As the mortality outcome decays as an exponential function,³³ it is of course regrettable that high acuity patients could not be fast tracked to the first available bed. However, not all beds are equal – those allocated to an outlying bed in our institution appeared to fare worse than admissions to the Acute Medical Admission Unit³⁴ and access block has been shown to impact detrimentally on the optimal disposition of patients.³⁵ But of course, this may be preferable to being on a ‘trolley’ in a crowded emergency department.

The question as to how ED wait times impact on clinical outcomes has been extensively studied without a satisfactory answer. In a literature review, Filippatos and Karasi³⁶ included 35 studies focusing on impact on delays in treatment interventions, increased medical errors / adverse events and increased mortality. They concluded that in aggregate the literature on ED over-crowding suggested poorer performance and adverse clinical outcomes, including mortality. Guttman and colleagues,⁹ in a cohort linked study, assessed the impact of long waiting times for non-admitted patients; for such patients treated in the emergency department there was a higher risk of death or hospital admission within seven days of the visit. The difficulty of course with estimating the effect of waiting time on outcomes is that outcomes can vary markedly; therefore one needs to objectively quantitate the baseline risk for each patients before one can estimate the extent to which that risk was altered by aliquots of ‘time to ward’ intervals. For the Risk Score the model adjusted range of 30-day episode mortality outcomes could range between 2.5% and 32.1%; for Manchester Triage the Odds Ratio of a hospital episode death by day 30 comparing ‘immediate’ versus ‘non-emergency’ was 12.4 (95% CI: 5, 31). And in the overall estimate of clinical risk, due weighting needs to be given to the

Mortality outcomes and emergency department wait times - the paradox in the capacity limited system

presence of comorbidity such as characterised by the Charlson Index,¹⁹ the presence of Chronic Disabling Disease²⁰ status or Sepsis.²² Most databases do not capture such data, so the precise impact of undue wait times on outcomes, distinguishing between causation rather than association, remains elusive. Our data however, illustrates another unappreciated problem – that patients are not accessing a hospital bed from the Emergency Department in an orderly queue based on time of arrival in the Emergency Department, but subject to a non-transparent triage system based on a perceived clinical need. As such it is bound to distort the simple relationship between wait times and clinical outcomes. But of course, a formal system based on an agreed evidenced based approach might be preferable.

Our data on the Risk Score information as far as we know, is novel from the point of view that it objectively based on laboratory data and coded diagnoses objectively characterised the Acute Illness Severity and Case Co-Morbidity / Complexity that could directly link the ED wait times with adverse clinical outcomes. Of course these data were not available in real time and indeed many of the subsequent deaths may be late after days or

weeks of in-patient care as we have described for weekend admissions.³³ Nonetheless the data suggest some objective basis that it may be possible to risk stratify those at high risk for time sensitive adverse outcomes and, in the face of ED capacity issues that cannot be readily solved due to resource constraint, at least endeavour to mitigate some of the worse consequence for an important subgroup.

Conclusion

Acute emergency services have demonstrated significant efficiencies in the face of increasing demand and diminished resourcing. Outcomes have improved but those patients at highest risk remain worthy of special attention. Those responsible for commissioning and funding services must maintain a critical focus on removing downstream access block to allow patients move to the most appropriate location for their care in a timely fashion, and care providers must endeavour to develop a queuing system that is informed by clinical risk.

Conflicts of interest

The authors declare that they have no conflict of interest regarding this publication.

References

- Langlands A, Dowdle R, Elliott A, Gaddie J, Graham A, Johnson G, et al. RCPE UK Consensus Statement on Acute Medicine, November 2008. *British journal of hospital medicine* (London, England : 2005). 2009;**70**(1 Suppl 1):S6-7.
- Conway R, O'Riordan D, Silke B. Long-term outcome of an AMAU-a decade's experience. *Quarterly Journal of Medicine*. 2014;**107**(1):43-9.
- Scott I, Vaughan L, D. B. Effectiveness of acute medical units in hospitals: a systematic review. *Int J Qual Health Care*. 2009;**21**(6):397-407.
- Byrne D, Silke B. Acute medical units: review of evidence. *Eur J Intern Med*. 2011;**22**(4):344-7.
- Rooney T, Moloney ED, Bennett K, O'Riordan D, Silke B. Impact of an acute medical admission unit on hospital mortality: a 5-year prospective study. *QJM*. 2008;**101**(6):457-65.
- Moloney ED, Smith D, Bennett K, O'Riordan D, Silke B. Impact of an acute medical admission unit on length of hospital stay, and emergency department 'wait times'. *QJM*. 2005;**98**(4):283-9.
- Hall MJ, Levant S, DeFrances CJ. Trends in Inpatient Hospital Deaths: National Hospital Discharge Survey, 2000-2010 2013 [Available from: <https://pdfs.semanticscholar.org/1ba6/6dde91e1ef7e8f7eb80da6423cf572bc24ce.pdf>].
- Plunkett PK, Byrne DG, Breslin T, Bennett K, Silke B. Increasing wait times predict increasing mortality for emergency medical admissions. *Eur J Emerg Med*. 2011; **18**(4): 192-6..
- Guttmann A, Schull MJ, Vermeulen MJ, Stukel TA. Association between waiting times and short term mortality and hospital admission after departure from emergency department: population based cohort study from Ontario, Canada. *BMJ*. 2011;342.
- Codd MB. Acute Hospital Bed Capacity - a National Review Dublin: Department of Health and Children, Ireland; 2002 [Available from: <http://health.gov.ie/wp-content/uploads/2014/04/Acute-Hospital-Bed-Capacity.pdf>].
- Mackway-Jones K, Marsden J, JWindle J. Emergency Triage (Second Edition). Group MT, editor. London: Blackwell Publishing Ltd; 2006.
- Byrne D, Cournane S, Conway R, Oriordan D, Silke B. Emergency Medical Admission Outcomes - Improved Survival Evidenced by Risk Score Comparator. *International Journal of Clinical & Medical Informatics*. 2018:1-10.
- Beeknoo N, Jones R. Factors Influencing A & E Attendance, Admissions and Waiting Times at Two London Hospitals. *British Journal of Medicine & Medical Research*. 2016;**17**(10):1-29.
- O'Loughlin R, Allwright S, Barry J, Kelly A, Teljeur C. Using HIPE data as a research and planning tool: limitations and opportunities. *Ir J Med Sci*. 2005;**174**(2):40-5; discussion 52-7.
- O'Callaghan A, Colgan MP, McGuigan C, Smyth F, Haider N, O'Neill S, et al. A critical evaluation of HIPE data. *Ir Med J*. 2012;**105**(1):21-3.
- Silke B, Kellett J, Rooney T, Bennett K, O'Riordan D. An improved medical admissions risk system using multivariable fractional polynomial logistic regression modelling. *Quarterly Journal of Medicine*. 2010;**103**(1):23-32.
- O'Sullivan E, Callely E, O'Riordan D, Bennett K, Silke B. Predicting outcomes in emergency medical admissions – role of laboratory data and co-morbidity. *Acute Medicine*. 2012;**2**:59-65.
- Courtney D, Conway R, Kavanagh J, O'Riordan D, Silke B. High-sensitivity troponin as an outcome predictor in acute medical admissions. *Postgrad Med J*. 2014:1-7.
- Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;**40**(5):373-83.
- Chotirmall SH, Picardo S, Lyons J, D'Alton M, O'Riordan D, Silke B. Disabling disease codes predict worse outcomes for acute medical admissions. *Intern Med J*. 2014;**44**(6):546-53.
- Cournane S, Conway R, Byrne D, O'Riordan D, Silke B. Predicting Outcomes in Emergency Medical Admissions Using

Mortality outcomes and emergency department wait times - the paradox in the capacity limited system

- a Laboratory Only Nomogram. *Computational and Mathematical Methods in Medicine*. 2017;**2017**(1):1-8.
22. Chotirmall SH, Callaly E, Lyons J, O'Connell B, Kelleher M, Byrne D, *et al*. Blood cultures in emergency medical admissions: a key patient cohort. *Eur J Emerg Med*. 2014.
 23. Litvak E, Bisognano M. More patients, less payment: increasing hospital efficiency in the aftermath of health reform. *Health Aff (Millwood)*. **2011**(30):76-80.
 24. Moses HI, Matheson D, Dorsey E, George B, Sadoff D, Yoshimura S. The anatomy of health care in the United States. *JAMA*. 2013;**18**:1947-63.
 25. Curfman G, Morrissey S, Drazen J. High-Value Health Care -- A Sustainable Proposition. *N Engl J Med*. 2013;**369**:1163-4.
 26. Lynch C, Holman C, Arcy J, Moorin RE. Use of Western Australian linked hospital morbidity and mortality data to explore theories of compression, expansion and dynamic equilibrium. *Australian health review : a publication of the Australian Hospital Association*. 2007;**31**(4):571-81.
 27. Walsh JB, Coakley D, Murphy C, Coakley JD, Boyle E, Johnson H. Demographic profile of the elderly population in Dublin accident and emergency hospital catchment areas. *Ir Med J*. 2004;**97**(3):84-6.
 28. Cournane S, Dalton A, Byrne D, Conway R, O'Riordan D, Coveney S, *et al*. Social deprivation, population dependency ratio and an extended hospital episode - Insights from acute medicine. *Eur J Intern Med*. 2015;**26**(9):714-9.
 29. Cournane S, Ann Dalton, Byrne D, Conway R, O'Riordan D, Coveney S, *et al*. Social deprivation, population dependency ratio and an extended hospital episode — Insights from acute medicine. *Eur J Intern Med*. 2015;**26**(9):714-9.
 30. Cournane S, Byrne D, Conway R, O'Riordan D, Coveney S, Silke B. Deprivation Index and Dependency Ratio Are Key Determinants Of Emergency Medical Admission Rates. *Eur J Intern Med*. 2015;**26**(9):709-13.
 31. Tian Y, Dixon A, Gao H. Emergency hospital admissions for ambulatory care-sensitive conditions: identifying the potential for reductions 2012 [updated Feb 16. 1-13]. Available from: http://www.kingsfund.org.uk/sites/files/kf/field/field_publication_file/data-briefing-emergency-hospital-admissions-for-ambulatory-care-sensitive-conditions-apr-2012.pdf.
 32. Cournane S, Byrne D, O'Riordan D, Fitzgerald B, Silke B. Chronic Disabling Disease – Impact on Outcomes and Costs in Emergency Medical Admissions. *Quarterly Journal of Medicine*. 2014:1-29.
 33. Conway R, Cournane S, Byrne D, O'Riordan D, Silke B. Survival analysis of weekend emergency medical admissions, *QJM*. 2017; **110** (5) 291-7
 34. Coary R, Byrne D, O'Riordan D, Conway R, Cournane S, Silke B. Outcome in relation to Healthcare Structure - The Acute Medical Admission Unit Experience. *Acute Medicine*. 2014; **13** (4): 152-8.
 35. Crilly J, Keijzers, Krahn D, Steele M, Green D, Freeman J. The impact of a temporary medical ward closure on emergency department and hospital service delivery outcomes. *Qual Manag Health Care*. 2011; **20**(4): 322-33
 36. Filippatos G, Karasi E. The Effect of Emergency Department Crowding on Patient Outcome. *Health Sciences Journal*. 2015;**9**:1-6.

Erratum

(Acute Medicine 2018; 17(2): 62-65) Page 62, Results on the patient flow of implementing an Acute Medical Unit.

Authors should read: SM Rombach, G Balke-Budai, J van Galen, R Bekker, SE Smit-Bruineberg, TH Biesheuvel, MHH Kramer & PWB Nanayakkara