

Research, Audit and Clinical Practice

The increased mortality associated with a weekend emergency admission is due to increased illness severity and altered case-mix

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Key Points

1. Mortality for medical emergency admissions, differed by weekday or weekend admission (weekend 11% higher).
2. The case mix differed at weekends with more respiratory and neurological diagnoses.
3. A predictive score (illness severity), based on age and disturbance in biochemistry, predicted a higher mortality for patients admitted at weekends.
3. The factors that were predictive of a death by day 30 were: Illness Severity Score, the Charlson Co-Morbidity Index, the serum albumin, oxygen saturation on presentation to ED and serum troponin status (negative or positive).

Abstract

Background: A weekend emergency medical admission has been associated with a higher mortality. We have examined all weekend admissions to St James' Hospital, Dublin between 2002 and 2009.

Methods: We divided admissions by weekday or weekend (Saturday or Sunday) presentation. We utilised a multivariate logistic model, to determine whether a weekend admission was independently predictive of 30 day outcome.

Results: There were 49337 episodes recorded in 25883 patients; 30-day in-hospital mortality at the weekend (9.9% vs. 9.0%) had an unadjusted Odds Ratio of 1.11 (95% CI 0.99, 1.23; $p=0.057$). In the full risk (unlike the univariate) model, a weekend admission was not independently predictive (OR 1.05; 95% CI: 0.88, 1.24). The case-mix for a weekend admission differed; with more neurological diagnoses (22.8% vs 20.4% : $p = 0.001$) and less gastrointestinal disease (18.3% vs 21.1% : $p = 0.001$). A biochemistry only illness severity score predicted a higher mortality for weekend admissions.

Conclusion: Patients admitted at the weekend had an approximate 11% increased 30-day in-hospital mortality, compared with a weekday admission. However, admission at the weekend was not independently predictive in a risk model that included Illness Severity (age and biochemical markers) and co-morbidity. Sicker patients, with a worse outcome, are admitted over the weekend; these considerations should inform the allocation of healthcare resources.

Keywords

Weekend, admission, mortality, patients case-mix.

Introduction

Over the past two decades there has been a growing interest in the association between weekend medical emergency admissions and mortality.

Acute-care hospitals operate differently during the week. At the weekend, there is less staff cover

(including physician coverage),¹⁻³ with a shift towards more junior, less experienced medical staff,⁴ and also reduced access to certain treatments and procedures.⁵⁻¹² Mortality is estimated on average to be 10% higher at the weekend^{1, 7, 11-21} perhaps related to staff or organisational rather than patient factors^{1, 5-6, 22-25}. Timely intervention can improve the outcome of patients with non-trauma life-threatening illnesses²⁶ including sepsis,²⁷ GI haemorrhage,²⁸ stroke,^{29,30} cardiac arrest^{31,32} and acute myocardial infarction.^{33,34} Additionally it appears that only 5% of urgent investigations such as fiberoptic bronchoscopy, esophageal gastroduodenoscopy, magnetic resonance imaging, echocardiography, ventilation-perfusion scanning, or coronary angiography are performed during weekends.⁸

Although it may appear reasonable to implicate the reduced availability of diagnostic procedures and therapeutic modalities at weekends, studies have failed to link higher weekend mortality rates to delays in procedure availability and timeliness.^{28,35,36} It has also been suggested that the case-mix could be different for weekend emergencies.^{5,9,24,37}

In this review of all emergency medical admissions to St James' Hospital between 2002 and 2009, we investigated whether mortality was in fact higher at weekends and if so whether organisational or patient factors could be implicated. We have a 30 day model of outcomes for emergency admissions with accurate prediction (90% AUROC). Our hypothesis was that, as structural factors in the healthcare system have not been built into the model, an independent prediction for a weekend admission in the full model would support resource deficiency arguments. Alternatively, the lack of independent outcome prediction, could imply altered weighting of predictors (between the weekday and weekend)

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already in the model, and support the inference of an epiphenomenon.

Methods

Background

St James's Hospital (SJH), in addition to national and regional roles, serves as a secondary care centre for emergency admissions for its local Dublin catchment area of 270,000 adults, operating a continuous sectorized acute general 'take' with patients directed towards surgical or medical specialties. All emergency medical admissions are referred to one of nine teams operating a 1:9 24 hr 'on-call' roster; this paper deals with any patient admitted under this General Medical service between 2002 and 2009. The operation and outcome of the acute medical admissions unit (AMAU) to 2007 has been described elsewhere.³⁸

Data collection

A dedicated patient database was created to link the computerized patient administration system (PAS) to the hospital in-patient 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.³⁹ 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 ICD-10-CM since then.

We used the Clinical Classifications Software (CCS) for ICD-9-CM – a diagnosis and procedure categorization scheme – to collapse the (>14,000 diagnosis codes) ICD-9-CM's multitude of codes into a smaller number (approx 240) of clinically meaningful categories that are more useful for presenting descriptive statistics than are individual ICD-9-CM codes. For example, CCS can be used to identify populations for disease- or procedure-specific studies or to develop statistical reports providing information (such as charges and length of stay) about relatively specific conditions.⁴⁰

The HIPE dataset of all coded diseases at 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 SJH between 1 January 2002 and 31 December 2009.

Derangement of hemodynamic and physiological admission parameters may be utilised to predict clinical outcome. We have previously derived and applied an Acute Illness Severity Score⁴¹ (AISS) for predicting in-hospital mortality at 5 or 30 days from the following six parameters routinely recorded in the Emergency Department(ED): age and basic laboratory tests, i.e. serum sodium (Na), serum potassium (K), serum urea, haematocrit and white blood cell count (WCC). This age and biochemistry score, with cut-offs at predicted 30 day mortalities of 1%, 2%, 4%, 8% and 16%, can be used as the basis to define groups at progressively increasing risk. However, at 30 days the AUROC for this age adjusted biochemistry model is only 0.85 (95% CI 0.84, 0.85).

It can be improved, as described below by the addition of other parameters that will be available within an hour or so following admission – the serum albumin, troponin status and the oxygen saturation.

The troponin status had three possible states – no test requested and tested with a value above or below the cut-off. Our assay for Troponin T had not sufficient sensitivity for a cutoff at the 99th percentile of a healthy reference population with a CV $\leq 10\%$. Therefore the deemed cutoff value of 0.01 ug/L was the lowest value at which the coefficient of variation was $\leq 10\%$. A positive value was therefore any value recorded $>$ of 0.01 ug/L.

Statistical methods

Descriptive statistics were calculated for background demographic data, including means/standard deviations (SD), medians/interquartile ranges (IQR), or percentages. Comparisons between categorical variables and 30-day in hospital mortality were made using chi-square tests. Significant predictors from univariate analyses ($p < 0.1$) were entered into a multivariable logistic regression model.

Logistic regression analysis was used to examine all significant outcome predictors ($p < 0.10$ from the univariate analysis) on 30-day in hospital mortality; in addition to the illness severity score, significant predictors included were Charlson co-morbidity index, Oxygen saturation and troponin status. We then used backwards stepwise methods to determine the optimal predictors, while testing the goodness-of-fit using the Hosmer and Lemeshow's (HL) test.⁴² The lack of significance in the HL test indicated a satisfactory goodness-of-fit for the model. The likelihood ratio statistics (LR χ^2 , df) and Pseudo R^2 value (derived from the deviance) are presented as goodness of fit statistics. We used this model to test the independence of a weekend admission as predictor of outcome.

Adjusted Odds ratios (OR) and 95% confidence intervals (CI) were calculated where appropriate. Statistical significance at $p < 0.05$ was assumed throughout. Stata v.11 statistical software was used for analysis.

Results

Patients (Table 1)

A total of 49337 episodes were recorded for patients admitted acutely via ED between 1 January 2002 and 31 December 2009. There were 25883 unique patients – the cohort studied for this report. These represented all medical admissions during the observation period, including patients admitted to the Intensive Care Unit (ICU) and High Dependency Unit (HDU). The data for unique patients' gender, their median age and length of stay, by weekday or weekend are shown in the Table 1.

The median (IQR) length of stay (LOS) was 4.7 (1.8, 9.2) days. The median (IQR) age was 58.4 (37.6, 75.7) years, with the upper 10% boundary at 83.9. The proportion of females (51.8%) was slightly higher than males (48.2%). The major disease categories were respiratory (22.6%), cardiovascular (16.2%), neurological (17.6%) and gastrointestinal (11.1%). The 30-day in-hospital mortality

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Variable	Weekday	Weekend	P value
Gender			
Male	9909 (48.4%)	2547 (47.7%)	0.28
Female	10569 (51.6%)	2808 (52.6%)	
Total	20478 (100%)	5335 (100%)	
Age (years)			
Median (SD)	56.6 (21.4)	56.6 (22.4)	0.99
Length stay (days)			
Median (SD)	6.9 (6.7)	6.3 (6.4)	< 0.001
Charlson Index			
0	11893 (58.1%)	3070 (57.5%)	0.99
1	4992 (24.4%)	1385 (26.0%)	
2	3593 (17.5%)	900 (16.9%)	
MDC Class			
Respiratory	4466 (21.8%)	1234 (23.0%)	< 0.05
Cardiac	3334 (16.3%)	873 (16.3%)	0.97
Neurological	3553 (17.4%)	1044 (19.5%)	< 0.001
GastroIntestinal	2328 (11.4%)	522 (9.8%)	< 0.001

Table 1. Details of Emergency Medical Admissions 2002 – 2009.

Diagnosis (CCS code)	Weekday (%)*	Weekend (%)	Chi ² p-value
Lower respiratory disease (133)	6.98	7.30	0.41
COPD and bronchiectasis (127)	2.97	3.64	0.01
Asthma (128)	2.27	2.76	0.04
Pneumonia (122)	4.11	4.72	0.05
Syncope (245)	4.07	5.17	0.001
Acute cerebrovascular disease (109)	3.21	3.85	0.02
Epilepsy / convulsions (83)	3.48	4.65	0.001
Congestive Heart Failure (108)	2.18	2.02	0.47
Headache including migraine (84)	4.04	3.45	0.05
Non-specific chest pain (102)	2.98	2.75	0.37
Urinary tract infection (159)	2.55	3.45	0.001
Skin infection / cellulitis (197)	2.18	2.67	0.03
Substance abuse (663)	1.18	0.86	0.05
Thrombophlebitis /thromboembolism (118)	1.82	1.20	0.002
Biliary tract disease (149)	2.63	0.67	0.001
* Percentages of total primary codings.			

Table 2. Primary diagnoses (CCS classification system) 2002 – 2009 related to a weekend OR weekday admission.

over the period averaged 9.2% (95% CI: 8.9% – 9.6%) but declined from 11.4% in 2002 to 5.3% in 2009 ($p<0.0001$). This represented a relative risk reduction of 53.2% over the period.

Weekend Admissions

A weekend admission was associated with an increased 30-day in-hospital death rate. The mortality for a weekday admission tended to be lower (9.0%; $p=0.057$) than for a weekend admission (9.9%). The univariate unadjusted

Odds Ratio of a weekend admission was of borderline significance (OR = 1.11 (95% CI 0.99, 1.23): $p=0.057$). There was a significant time effect observed in regard to weekend mortality (Figure 1); since the inception of the AMAU, the mortality for a weekend admission declined (RRR 62.2%) from 13.5% in 2002 to 5.1% in 2009.

Patients admitted during the weekend did not have the same risk profile as those admitted on a weekday. Although the age ($p=0.99$) and Charlson Comorbidity Index ($p=0.99$) and time to medical referral ($p=0.12$) and numbers with

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Variable	Variable	Odds Ratio	[95% CI]	p-value
Illness Score	Grp 2 vs 1	1.72	0.87, 3.40	0.12
	Grp 3 vs 1	4.66	2.65, 8.20	<0.001
	Grp 4 vs 1	6.51	3.82, 11.1	<0.001
	Grp 5 vs 1	10.00	5.93, 16.9	<0.001
	Grp 6 vs 1	19.93	12.0, 33.2	<0.001
Charlson Index	Grp 1 vs 0	1.09	0.88, 1.35	0.42
	Grp 2 vs 0	1.70	1.39, 2.08	<0.001
Albumin		0.22	0.18, 0.26	<0.001
O2 Saturation		0.14	0.09, 0.20	<0.001
Troponin	Neg vs None	0.70	0.56, 0.88	0.003
	Pos vs None	3.29	2.71, 3.99	<0.001

Table 3. Final logistic regression model to predict a 30-day in-hospital death.

cardiological diagnoses were similar, there were more patients with respiratory (23.0% vs 21.8% : $p < 0.05$), kidney (4.9% vs 4.4% : $p = 0.056$) and neurological disease (19.5% vs 17.4% : $p = 0.0005$) and fewer with gastrointestinal (9.8% vs 11.4% : $p = 0.001$) and hepatobiliary (2.7% vs 6.4% : $p < 0.0001$) disease presenting as a weekend medical emergency. Mortality was higher between 2002 and 2009 for patients with a primary respiratory diagnosis (15.0% vs 7.5%: $p < 0.0001$) but less for those with a primary neurological (7.7% vs 9.5%: $p < 0.0001$) or gastrointestinal diagnoses (4.8% vs 9.8%: $p < 0.0001$). The CCS classification for the top 50% of primary diagnoses is tabulated in Table 2; the bulk of these primary diagnoses were more frequent at the weekend.

It was possible to estimate 30-day in hospital mortality rate from the MFP biochemical model;^{41, 43} this model based on the age weighted biochemical disturbance (internal mileau) predicted weekday mortality to be lower ($p = 0.0004$) at 8.8% compared with the weekend cohort 9.7%. These predicted rates were not materially different than those observed.

Logistic Regression Model

All significant factors in the univariate analysis were predictive of in hospital death by day 30 including the Illness Severity Score, the Charlson Co-Morbidity Index, the serum albumin and initial oxygen saturation in the Emergency Room and the serum troponin value (negative or positive) (Table 3). The LR χ^2 statistic (2139.6, 11) was highly significant ($p < 0.0001$) and the Pseudo R^2 was 0.354.

In a random 80% derivation sample of the dataset, the AUROC to predict inhospital death at 30 days was 0.90 (95% CI: 0.89, 0.91), with a Hosmer-Lemeshow $\chi^2(8)$ value = 13.3 ($p = 0.10$). The observed mortalities for the 6 groups, based on the predicted 1%, 2%, 4%, 8% and 16% cutoffs were 0.5, 1.5, 2.8, 6.7, 12.4 and 27.8% respectively. In the 20% internal validation subset, the AUROC to

predict a death at 30 days was 0.91 (95% CI 0.89, 0.92), with a Hosmer-Lemeshow $\chi^2(8)$ value = 10.4 ($p = 0.24$). The observed mortalities for the same six risk groups, in the validation set, were 0.6, 0.8, 1.9, 4.7, 8.0 and 21.1% respectively.

A weekend admission, in this model, was not independently predictive of in-hospital mortality (OR 1.05; 95% CI: 0.88, 1.24).

Discussion

These data add to the knowledge base surrounding weekend care provision, and specifically contribute to the debate on mortality associated with a weekend hospital admission due to a medical emergency. It is clear that the case-mix of patients may alter at the weekend, with implications for the resultant outcome. Laboratory data, reflecting the internal disturbed milieu, may be useful in predicting outcome;⁴³⁻⁴⁶ our MFP laboratory model predicted weekend mortality should be of the order of 9.7% (observed – 9.9%) compared with a weekday prediction of 8.8% (observed 9.0%). These data showing that both the case-mix and the illness severity were altered at the weekend suggest that conclusions of service deficits to explain higher weekend mortality rates are not warranted.

Aylin and colleagues⁴⁷ using routinely collected hospital administrative data, examined in-hospital deaths for emergency inpatient admissions to all public acute hospitals in England for 2005/2006. Odds of death, for a weekend emergency admission, were 10% higher (OR 1.10, 95% CI 1.08 to 1.11). This figure is very close to that estimated from our large series over eight years (OR = 1.11, 95% CI 0.99, 1.23). The authors did mention possible confounding due to altered case-mix between patients admitted during the week and at weekend and attempted to adjust for this possibility.

It is possible that patients admitted at weekends may have a higher co-morbidity and therefore a worse

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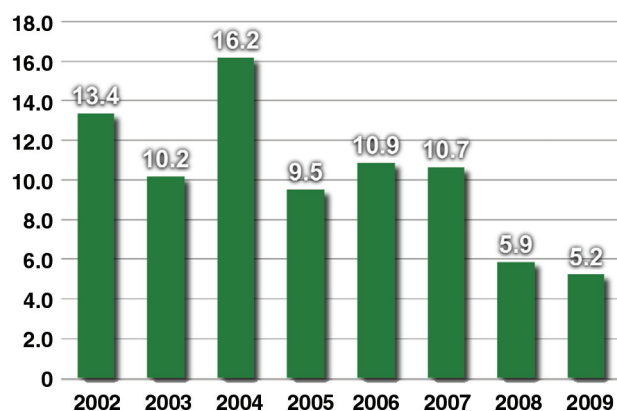


Figure 1. The 30-day in hospital mortality for the weekend cohort (ED presentation on Saturday or Sunday) declined (RRR 60.8%) between 2002 and 2009.

outcome. We measured the Charlson Index⁴⁸ as a marker of co-morbidity but co-morbidity unlike case mix did not differ for patients presenting at the weekend. As the Charlson Index is weighted towards the extreme and complex, it may not be the optimal adjustor as previously suggested.⁴⁹

We have previously derived and applied an Acute Illness Severity Score (AISS)⁴¹ for predicting in-hospital mortality from routinely recorded biochemical parameters. Other workers, such as Froom and Shimoni⁵⁰ have demonstrated that electronically retrieved laboratory data might be used as a potential quality indicator to predict mortality in internal medicine departments. In the present case, the model clearly showed that an approximate 10% higher weekend mortality would be consistent with the age weighted biochemical disturbance.

Thus while concerns have been raised about reduced hospital staffing during weekends⁴ and the availability of

important intensive medical treatments,⁵ our data implicates patient factors. Although delays in investigation and treatment during weekends are clear, whether these delays and increased mortality rates are causative or associated has been a quandary.^{28, 35, 36} Our data clearly suggests that the weekend effect is largely attributable to an increase in illness severity and an altered case-mix. Of course, if patients have an increased illness severity and an anticipated worse survival outcome, these factors are pertinent to resource allocation decisions when planning healthcare delivery.

Limitations

This single centre retrospective study focusses on emergency department admissions for medical emergencies, which constitute over 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 were orthopaedic and surgical cases. Also we did not have data on patients who might die after discharge or who presented to Emergency Department but were discharged without admission.

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