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Original Article

Time patterns in mortality after an emergency medical admission; relationship to weekday or weekend admission

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ABSTRACT

Background: The aim of this study was to detail the time profile and frequency distribution of mortality following an emergency admission and to compare these for weekday and weekend admissions.
Methods: We profiled in-hospital deaths following emergency medical admission between 2002 and 2014. We determined the frequency distribution, time pattern, causality and influence of day of admission on mortality out to 120 days. We utilized a multivariable regression model (logistic for in-hospital mortality and truncated Poisson for count data) to adjust for major predictor variables.
Results: There were 82,368 admissions in 44,628 patients with 4587 in-hospital deaths. The 30-day in-hospital mortality declined from 8.2% in 2002 to 3.7% in 2014. The mortality pattern showed an exponential decay over time; the time to death was best described by the three-parameter Weibull model. The calculated time to death for the 5th, 10th, 25th, 50th, 75th, and 90th centiles were 0.5, 1.2, 3.8, 11.1, 26.3 and 49.3 days. Acute Illness Severity Score, Chronic Disabling Disease Score, Charlson Co-Morbidity Index and Sepsis status were associated with mortality. The risk of death was initially high, lower by day 3, and showed a cumulative increase over time. The mortality pattern was very similar between a weekday or weekend admission; however, the risk of death was greater at all time points between 0 and 120 days for patients admitted at a weekend OR 1.08 (95% CI 1.01–1.15).
Conclusion: We have demonstrated the pattern of mortality following an emergency admission. The underlying pattern is similar between weekday and weekend admissions.

1. Introduction

Acute medicine focuses on the immediate management of patients requiring emergency admission [1]. The process of care delivery influences patient outcomes; improved outcomes have occurred with reforms such as care delivery via an acute medical admissions unit (AMAU) [2–4], other structural reforms [5,6] and the presence of senior consultant interventions [7]. Demographic changes combined with the complex medical needs of an ageing population necessitates investment in acute care delivery; increased life expectancy (by 9.2 and 9.4 years for males and females respectively from 1970 to 2010), has been coupled with an increased time spent living with chronic ‘disabling’ conditions by 4.0 and 2.6 years for males and females respectively in the same time period [8].

Consequently, the complexity and costs of acute healthcare delivery can be anticipated to increase. Another topic that has excited considerable controversy has been the association between weekend medical emergency admissions and mortality; mortality has been estimated on average to be 10% higher at the weekend [9–13]. It is difficult to undertake fair comparisons, implicating the performance of health care providers as substandard, without due allowance for factors such as deprivation status between catchment areas that will have a major impact on hospital admission incidence rates [14–18] and healthcare outcomes [19]. Clinical complexity reflected in risk predictors such as the Charlson Co-morbidity index [20], the extent of Chronic Disabling Disease [21,22], Acute Illness Severity Score [23,24] or Sepsis status, will all substantially impact on the in-hospital mortality rate [25]; however these descriptors are often not available in comparisons that come to sweeping conclusions.

There is very little data in the literature on the time course and pattern of death following an emergency medical admission, much less how this might be modulated by a weekend or weekday admission. The aim of this study was to address this deficiency by characterizing the frequency distribution pattern of death following an emergency medical admission and to compare this distribution between weekday and weekend admissions.

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2. Methods

2.1. Background

St James's Hospital serves as a secondary care centre for emergency admissions for its local Dublin catchment area of 220,000 adults. All emergency medical admissions are referred to one of nine teams operating a 24 h on-call roster. Emergency medical patients are admitted from the Emergency Department to an AMAU opened in 2003, under the care of the on-call general internal medicine physician. The AMAU is a 59-bedded unit with acute care provided by experienced nurses specialized in acute medicine. The operation and outcome of the AMAU have been described in detail previously [2–4].

2.2. Data collection

For audit purposes we employed an anonymous patient database assembling core information about each clinical episode from elements contained on the national hospital in-patient enquiry (HIPE) scheme, the patient electronic record, the Emergency Department and laboratory systems. HIPE is a national database of coded discharge summaries from acute public hospitals in Ireland [26,27]. 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 ICD-10-CM since then.

Data held on the database includes 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 physiological, haematological and biochemical parameters are recorded.

2.3. Co-morbidity

We used discharge codes to calculate the Charlson Co-morbidity index to evaluate co-morbidity [20].

2.4. Acute illness severity score

Derangement of hemodynamic and physiological admission parameters may be utilized to derive an Acute Illness Severity Score that predicts clinical outcomes [23,24]. From modelling laboratory data collected at time of hospital admission we developed a predictive algorithm based on serum sodium, potassium, urea, albumin, red cell distribution width, and white blood cell count. The underlying principle is that deviation beyond the boundaries of 'normal homeostasis' is an estimate of risk, although the relationship is non-linear and differs for each variable. This Acute Illness Severity Score has been used as a risk adjustor in our multivariable model [23,24].

2.5. Chronic disabling disease score

We have previously described a Chronic Disabling Disease Score, derived from counts of discharge ICD9/ICD10 codes, that strongly correlated with mortality and length of stay [21]. Between January 2002 and December 2014 with 82,368 episodes in patients admitted as a medical emergency, only 11.4% of such episodes had a Chronic Disabling Disease Score of 0. There is the possibility for conditions to contribute to both the Charlson Co-Morbidity Index and the Chronic Disabling Disease Score, however our previous work has shown both to be independent predictors of mortality [21].

2.6. Sepsis status

Sepsis status was divided into three categories on the basis of blood culture results: no blood culture request, negative blood culture result, and positive blood culture result. Their respective frequencies were 75.4%, 20.5% and 4.1% with 30-day in-hospital mortality rates of 5.5%, 16.1% and 30.5% respectively [25].

2.7. Weekday or weekend admissions

For the purposes of this study we divided patients into weekday (Monday to Thursday) or weekend (Friday to Sunday) admissions based on the day on which they were initially admitted to hospital.

2.8. Statistical methods

Data for this study relates to all medical admissions from 2002 to 2014. Individual patients may have been admitted on more than one occasion over the study period, a small number of patients were admitted on more than 50 occasions over the 12 year period. It is necessary to adjust the analyses for these multiple admission patients in some fashion in order to optimize the predictive value of the resulting models. Clearly patients with multiple admissions are different to those with only one or a small number of admissions, however at the time of admission (for the most part) it is not clear which group the patient belongs to. In order to optimize the predictive value of the model we elected to randomly select an admission for each patient with multiple admissions to run the analyses.

Descriptive statistics were calculated for background demographic data, including means/standard deviations, medians/interquartile ranges, and numbers/percentages. Comparisons between categorical variables and 30-day in hospital mortality were made using chi-square tests. 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 Acute Illness Severity Score, significant predictors were Charlson Co-morbidity Index [20], Chronic Disabling Disease Score [21] and sepsis status [25]. We then used backwards and forwards stepwise methods to determine the optimal predictors, while testing the goodness-of-fit using the Hosmer and Lemeshow's tests. The latter test is based on the expectation, that the predicted and observed frequency should match closely, and that the more closely they match, the better the fit. We used this model to test the independence of a weekend admission as predictor of outcome. Odds Ratios (OR), Relative Risk Reduction (RRR), and Number Needed to Treat (NNT) were calculated where appropriate. Statistical significance at $p < 0.05$ was assumed throughout. Stata v.13 statistical software (Stata Corporation, College Station, Texas) was used for analysis.

3. Results

3.1. Patients

A total of 82,368 admissions were recorded in 44,628 patients between 1 January 2002 and 31 December 2014. These represented all emergency medical admissions during the observation period, including patients admitted to the Intensive Care Unit and High Dependency Unit. There were 4587 in-hospital deaths over this 13 year period.

In the entire cohort the median (interquartile range (IQR)) length of stay was 5.4 (2.3 to 10.2) days. The median (IQR) age was 65.3 (45.4 to 78.8) years, with the upper 10% boundary at 83.9 years. The proportion of females (51.3%) was slightly higher than males (48.5%). The major disease categories were respiratory (25.4%), cardiovascular (16.1%), neurological (16.8%) and gastrointestinal (10.2%).

The comparison of patient characteristics by mortality (hospital death on any admission), is shown in Table 1. Patients who died were older, 80.0 years (95% CI 70.8, 86.0) vs 63.1 years (95% CI 42.8, 77.7) ($p < 0.001$). Their average stay in hospital was longer at 12.3 days (95% CI 3.8, 20.5) vs 5.8 days (95% CI 2.3, 12.2) ($p < 0.001$). They were more likely to have had a previous admission. Markers of clinical complexity such as Acute Illness Severity Score, Chronic Disabling Disease