Hospital Readmissions – Independent Predictors of 30-day Readmissions derived from a 10 year Database

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Abstract

Unplanned medical 30 day readmissions place a burden on the provision of acute hospital services and are increasingly used as quality indicators to assess quality of care in hospitals. Multivariable logistic regression of a 10 year database showed that four factors were most strongly associated with early readmission: [1] Charlson comorbidity index >=1, [2] respiratory disease as a principal diagnosis, [3] liver disease and alcohol-related illness as an additional diagnosis, and [4] the number of previous readmissions. Disease and patient-related factors beyond control of the hospital are the factors most strongly associated with 30 day readmission to hospital, suggesting that this may not be an appropriate quality indicator.

Keywords

Prediction Models, Patient-specific factors, Disease-specific factors, Healthcare-Specific factors, Quality Indicators

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Key points

- Readmissions are associated with Disease-Specific, Patient-Specific and Healthcare-Specific factors
- Four factors were most strongly associated with early readmissions: [1] Charlson comorbidity index (CCI) >/=1, [2] respiratory disease as a principal diagnosis, [3] liver disease and alcohol-related illness as an additional diagnosis, and [4] the number of previous readmissions
- The use of 30 day Readmissions as a hospital quality indicator is questionable

Introduction

Hospital readmissions within 30 days of discharge are common and costly [1], and have been used to raise questions about the quality of care during the initial hospitalization.[2] NHS data show that the average 28 day readmission rate in the UK is 10.6%.[3] In Ireland the 30 day Readmission Rate is 9.5% while in the United States, nearly 20% of Medicare beneficiaries discharged from acute care hospitals are readmitted within 30 days, incurring additional costs of several billion dollars annually.[4, 5]

Most current readmission risk prediction models perform poorly. A recent systematic review of risk prediction models for hospital readmissions found fourteen models (relying on retrospective administrative data) that could be potentially used to risk-adjust readmission rates for hospital comparison; of these, 9 were tested in large US populations and had poor discriminative ability (c statistic range: 0.55-0.65). Seven models could potentially be used to identify high-risk patients for intervention early during a hospitalization (c statistic range: 0.56-0.72), and 5 could be used at hospital discharge (c statistic range: 0.68-0.83). Six studies compared different models in the same population and two of these found that functional and social variables improved model discrimination.[6] Therefore, in our opinion, these prediction tools have not been validated to predict readmissions in different populations worldwide and overall show low to moderate discriminatory power.[7]

This paper used a multivariable logistic regression model to identify independent predictors of 30 day hospital readmissions. A 10 year database (2002 to 2011) of acutely ill medical patients admitted to an Acute Medical Admissions Unit of an Irish tertiary care hospital was analysed.

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. Emergency medical patients are admitted from the Emergency Department (ED) to an Acute Medical Admissions Unit (AMAU). This unit opened in 2002 and has a 59-bed capacity. Up to 70% of all admissions can be predicted to receive their entire hospital care within the maximum permitted stay of 5 days in the AMAU. The operation and outcome of the AMAU to 2007 has been described elsewhere.[8]

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 Environmental Systems Research Institute.[9] For ease of discussion we will refer to the cohort as admissions rather than discharges. Ireland has 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.[10-12]

Linking the HIPE dataset with the PAS dataset permits interrogation of routinely collected data for the purposes of research, planning and quality control. Data held on the database includes the unique hospital number, admitting consultant, date of birth, gender, 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 cross-linked and automatically uploaded to the database includes physiological, haematological and biochemical datasets and the emergency attendance triage category and basic haemodynamic datasets.

The HIPE dataset of all coded diseases at time of discharge/death, together with procedures and investigations undertaken during the hospital stay, were examined. Data related to all emergency general medical patients admitted to and discharged from SJH between 1 January 2002 and 31 December 2011. Patients who died in hospital were excluded from the analysis. In addition, there are a number of patients in the database who were in hospital on a long-stay basis These long-stay patients were not comparable to the general medical patient population as they were likely to be hospitalised for longer periods due to different factors, for example social rather than medical factors. The inclusion of these patients may obscure any association between length of stay and risk of readmission among general medical patients, and may distort the data. To exclude these patients, only admissions with a length of stay of 30 days or less were included in the analysis.

Measures

Multiple admissions by the same patient were identfied using a unique patient identifier. We calculated the time in days between consecutive admissions, with a cut-off of 30 days between any hospital episode and a subsequent admission being classified as an early readmission.

Potential predictors of early readmission included patient-specific factors (age and sex), disease-specific factors (principal diagnosis, additional diagnoses, charlson comorbidity index, urea, haemoglobin), and health-care related factors (length of stay, year of admission, and number of previous readmissions). All variables were measured at the index admission – i.e., the episode prior to the early readmission.

Principal diagnoses were categorised using the Major Diagnostic Categories (MDC) classification, ICD-10. A broad range of additional diagnoses were also examined, ranging from alcohol-associated diseases, congestive heart failure, tumour, gastrointestinal bleed, liver disease, diabetes complications, stroke and pneumonia. Only principal and additional diagnoses that were assigned to at least 1,000 general medical episodes (equivalent to 1.8% of total episodes) were examined, to ensure sufficient numbers of readmissions for analysis. Comorbidity was measured using the Charlson Index, which assigns a score based on the number and severity of specific conditions.[13]

Statistical methods

Descriptive statistics were calculated for background demographic data, including means/standard deviations (SD), medians/interquartile ranges (IQR), or percentages. The association between each predictor and the odds of readmission, adjusted for age, sex and charlson index, was examined using logistic regression. Any variables that were statistically significant at a $p<0.01$ level in these base-adjusted models was entered into a fully-adjusted multivariable logistic regression. STATA version 12.1 was used for analysis.[14]

Results

A total of 61,578 episodes of admission were recorded for patients admitted acutely via the Emergency Department between January 1st 2002 and 31st December 2011, and discharged within the same time period. The 3,607 (5.9%) discharges who died, and the 4,994 discharges (8.1%) who survived but had a length of stay greater than 30 days were excluded, giving a total of 52,977 episodes. The episodes recorded represented all medical admissions during the observation period, including patients admitted directly to the Intensive Care Unit and High Dependency Unit.

The annual number of disharges ranged from 5,476 (2002) to 6,652 (2005). The average age of discharges was 57.9 years (SD=20.7, Median=60.5 IQR=40.5-75.9), and 50.7% were female. The average length of stay was 6.8 days. During the 10 year study period 4,533 discharges were readmitted within 30 days of an index admission. The overall 30 day readmission rate was 8.6% with little variability year on year (Figure 1) (chi-sq= 15.7, p = 0.07).

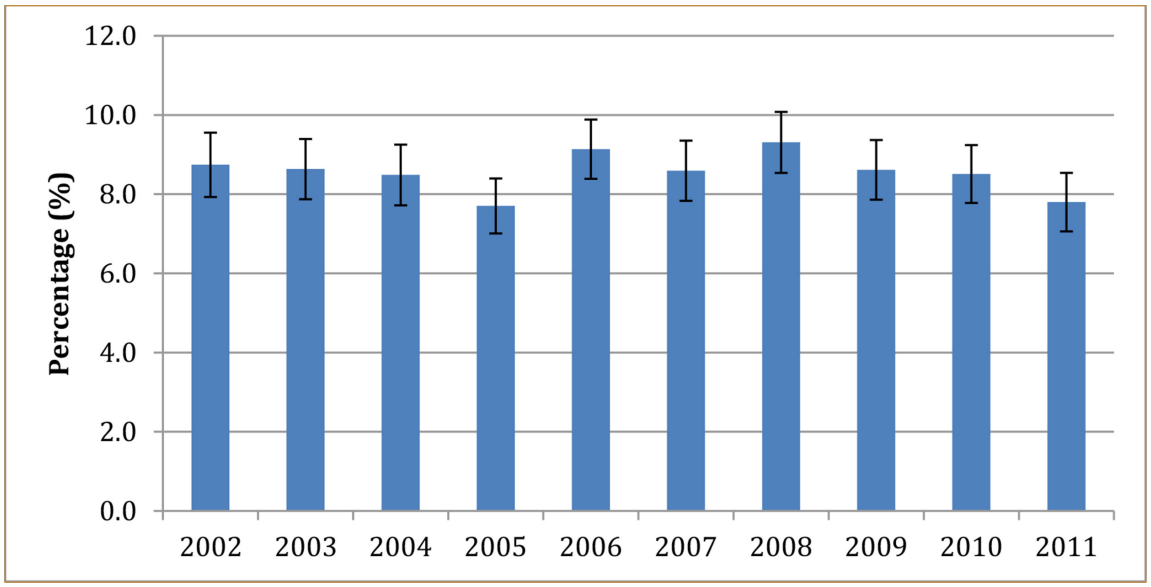

Figure 1. 30-day readmission rate by year, 2002-2011, with 95% confidence intervals

The patient-specific, disease-specific and health-care specific factors, each adjusted for age, sex and comorbidity (Charlson index) associated with early readmission were determined. The factors most strongly associated with early readmission were: Charlson comorbidity index (CCI) >=1 (after correction for age, sex and CCI), respiratory disease as a principal diagnosis, liver disease and alcohol-related illness as an additional diagnosis, and the number of previous readmissions (Table 1).

Compared to patients who were not readmitted within 30-day days of discharge, readmitted patients had a longer average length of stay both during their

Table 1. Readmission rates associated with Patient-Specific, Disease-Specific and Healthcare-Specific factors, each adjusted for age, sex and comorbidity (Charlson index).

Variable	Number of readmissions	Readmission Rate	Odds ratio	95% CI		P value
Total Sample	4,533	8.56				
Patient-Specific Factors						
Age (in years)*	-	-	0.99	1.00	1.00	0.419
Female Sex	2,036	7.57	0.78	0.71	0.87	<0.01
Charlson Index (0 = ref)	1,709	6.17	-	-	-	-
1	1,623	10.45	1.78	1.63	1.95	<0.01
2	1,201	12.31	2.13	1.90	2.39	<0.01
Disease-Specific Factors						
Major Diagnostic Category						
MDC 1 (CNS)	455	5.44	0.58	0.52	0.65	<0.01
MDC 4 (Respiratory system)	1,636	12.08	1.56	1.43	1.70	<0.01
MDC 5 (Circulatory system)	632	7.35	0.83	0.75	0.91	<0.01
MDC 6 (Digestive system)	543	9.05	1.17	1.05	1.30	<0.01
MDC 7 (Hepatobiliary system)	318	11.29	1.31	1.13	1.52	<0.01
MDC 8 (Musculoskeletal system)	102	5.95	0.74	0.60	0.91	<0.01
MDC 9 (Skin, subcutaneous tissue)	138	7.72	0.96	0.79	1.17	0.68
MDC 10 (Endocrine, nutritional and metabolic)	145	7.99	0.80	0.64	1.00	0.05

MDC 11 (kidney and urinary tract)	146	6.93	0.83	0.69	0.99	0.04
MDC 21 (Injuries, poisonings and toxic effects of drugs)	68	4.81	0.69	0.54	0.89	<0.01
Co-morbidity						
Liver disease	1,178	12.51	1.51	1.37	1.67	<0.01
Alcohol	629	14.01	1.73	1.52	1.97	<0.01
Congestive heart failure	708	12.36	1.25	1.12	1.40	<0.01
Atrial fibrillation	458	10.49	1.10	0.96	1.26	0.16
Urea*	-	-	1.00	0.99	1.01	0.83
Haemoglobin*	-	-	0.91	0.90	0.93	<0.01
Stroke	127	5.16	0.41	0.33	0.49	<0.01
COPD	1,732	12.42	1.50	1.36	1.65	<0.01
Pneumonia	215	9.01	1.03	0.89	1.21	0.669
Hyponatraemia	479	11.48	1.34	1.15	1.55	<0.01
Hypokalaemia	152	10.83	1.36	0.12	1.64	<0.01
Uraemia	1,281	9.81	1.12	1.00	1.26	0.04
Anaemia	987	12.23	1.53	1.38	1.70	<0.01
Acute myocardial infarction	374	9.13	1.04	0.88	1.23	0.664
Tumour	253	9.66	0.76	0.63	0.91	0.004
Ischaemic Heart Disease	1,239	9.21	0.99	0.9	1.09	0.900
GI bleed	93	8.16	0.86	0.69	1.08	0.201
Sepsis	177	7.74	0.93	0.79	1.09	0.382
Diabetes complications	140	10.08	0.89	0.66	1.21	0.457
Hyperthermia	712	8.23	0.81	0.73	0.90	<0.01
Syncope	180	4.70	0.55	0.47	0.65	<0.01
Seizure	175	6.86	0.86	0.73	1.02	0.08
Headache	100	4.95	0.68	0.56	0.84	<0.01
Confusion	91	6.71	0.74	0.58	0.93	0.01
Cellulitis	95	7.99	0.92	0.73	1.15	0.46
UTI	244	7.35	0.92	0.80	1.06	0.24
Gastritis	161	10.11	1.10	0.91	1.32	0.32
Health-Care Specific Factors						
Length of stay*	-	-	1.00	0.99	1.00	0.61
Previous readmission	2,321	17.96	3.40	3.13	3.69	<0.01
Year of discharge*	-	-	0.98	0.97	1.00	0.07

*Measured as a continuous variable

index admission (7.17 vs 6.76 days, p <0.001) and during the readmission episode itself (7.59 vs 6.73 days, p <0.001). However, the median lengths of stay were the same for both admissions and re-admissions (6.5 days), and the difference in average length of stay was no longer significant once adjusted for age, sex and comorbidity.

The following were identified by logistic regression as independent predictors of readmissions: male gender, four major diagnostic categories (i.e. circulatory, respiratory, digestive and hepato-biliary), four comorbidities (i.e. liver diease, alcohol related illness, COPD, hyponatraemia and heart failure), Charlson index, and a previous readmission (Table 2). The following factors were associated with significantly reduced risk of readmission: disease of the nervous system as major diagnostic category, higher haemoglobin levels and syncope as an additional diagnosis. The AUROC of this model was 70% (see Figure 2).

Table 2. Fully-adjusted logistic regression model of readmission

Variable	Odds Ratio	SE	P value
Age (in years)	1.00	0.00	0.231
Female Sex	0.79	0.04	<0.01
Charlson Index (0 = ref)			
1	1.24	0.06	<0.01
2	1.30	0.08	<0.01
MDC 1	0.86	0.06	0.04
MDC 4	1.34	0.08	<001
MDC 5	1.11	0.07	0.102
MDC 6	1.26	0.08	<0.01
MDC 7	1.28	0.10	0.002
MDC 8	0.86	0.10	0.21
MDC 21	0.77	0.10	0.055
Co-morbidity			
Liver disease	1.15	0.06	0.003
Alcohol	1.34	0.08	<0.01
Congestive heart failure	1.15	0.07	0.016
Haemoglobin	0.95	0.01	<0.01
Stroke	0.81	0.09	0.054
COPD	1.13	0.06	0.017
Hyponatraemia	1.23	0.09	0.004
Hypok	1.15	0.11	0.131
Anaemia	1.09	0.07	0.194
Tumour	0.94	0.09	0.518
Syncope	0.62	0.05	<0.01
Headache	1.01	0.12	0.902
Previous readmission	2.99	0.12	<0.01

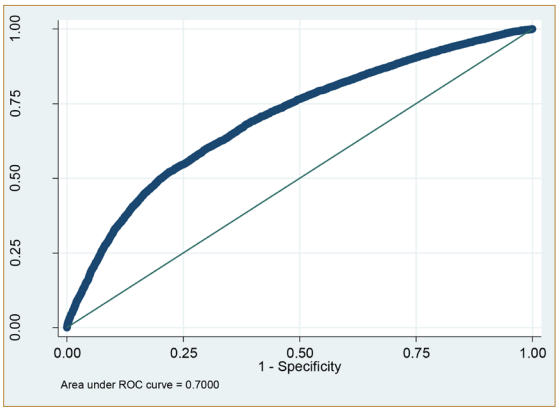

Figure 2. AUROC of readmission prediction model using logistic regression analysis

Discussion

Many studies have been performed worldwide to identify risk factors associated with readmissions along with the derivation of hospital readmission prediction tools.[15, 16] However, these prediction tools have not been validated to predict readmissions in different populations worldwide and overall show low to moderate discriminatory power.[7, 17] Using logistic regression this study identifies the following factors associated with an increased risk of readmission within 30 days: Charlson comorbidity index >=1, respiratory disease as a principal diagnosis, liver disease and alcohol-related illness as an additional diagnosis and the number of previous readmissions. Co-morbidities such as low hemoglobin levels, heart failure and male sex were also strongly associated with increased 30 day readmissions. In previous work, many risk factors associated with 30 day readmissions were non-modifiable disease-related factors, such as the natural progression of underlying disease or unavoidable recurrence of disease.[18-22] The risk factors identified in our cohort were mostly disease-related but also patient-elated (e.g.,alcohol) the latter being potentially modifiable.

Hospital readmissions are widely used as an indicator of the quality of care during a patient's index admission and recently penalty systems to hospitals have been introduced for readmitted patients. The Hospital Readmissions Reduction Program (HRRP) in the United States believes that readmissions indicate poor quality of care during the index admission. This program therefore introduced a penalty system in October 2012 whereby Medicare reimbursements would be reduced for hospitals that have "excess" readmissions for Heart Failure, Acute Myocardial Infarction and Pneumonia.[23] More recently, penalties and strict quality measures for readmitted patients have been introduced in some European countries.[24] The United Kingdom Society for Acute Medicine (SAM) standards use 7 day readmission as the indicator of quality for AMUs, on the basis that it is the early readmissions that tend to relate to factors that might be influenced by hospital stay, whereas later readmission tends to relate to disease-related or community related factors. Seven day readmissions may still be a useful quality indicator.

However, during the ten years of this study the Irish economy experienced a dramatic reversal. From 2002 until 2007 the Irish economy was amongst the fastest growing in the world and considerable investments in the health service were made. In 2007 there was a dramatic change in Ireland economic fortunes and draconian cuts in the health service were made. Those of us working in the service subjectively felt that our care had become more

chaotic, perfunctory and of far lower quality. Despite these changes in service delivery between 2002 and 2011, the readmission rate in our institution remained remarkably constant year on year. In our opinion, if healthcare-related factors were major contributors to readmissions we would have expected to be able to demonstrate more variation in the readmission rates of the different medical teams caring for patients over the years. We would also have expected some variation over time.

Punitive measures for readmissions focus on hospitals as the locus of accountability for the problem rather than viewing readmissions within a broader context of patient-related, disease-related and healthcare-related factors.[23] We believe that disease-related and patient-related factors, which are mostly beyond control of hospitals are strongly associated with unexpected readmissions and that 30 day readmission rates should not be used as an independent indicator of the quality of in-hospital care.

Conflicts of interest

None

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