European Journal of Epidemiology 16: 1017–1021, 2000.

Prediction of mortality for congestive heart failure patients: Results from different wards of an Italian teaching hospital

N. Nante[1], M.F. De Marco[1], D. Balzi[2], P. Addari[3] & E. Buiatti[2]
[1] *Istituto di Igiene, Università di Siena;* [2] *Unità Operativa di Epidemiologia ASL 10-Florence;* [3] *Direzione Sanitaria, Azienda Ospedaliera Senese, Italy*

Accepted in revised form 22 December 2000

Abstract. Congestive heart failure (CHF) constitutes an important public health problem in Italy, evidenced by the high number of hospital admissions each year. Significant inter-hospital as well as inter-ward differences in mortality rates for CHF patients that have been described may, in part, be explained by the differences in the severity of the illness of admitted patients. The goal of this study was to predict 30-day severity-adjusted mortality risk in patients with CHF admitted to wards of a teaching hospital in Siena, Italy, in 1997. A 30-day mortality was determined by linking hospital discharge files with the Tuscany Mortality Registry database. The 3M all patient refined diagnosis related group (APR-DRG) software was used as a risk assessment method. The relationships between death and the following variables were studied by univariate analyses: APR-severity risk, APR-mortality risk, age, sex, length of stay and, discharge ward. Multivariate analysis was also performed to verify the associations between death and those parameters found to be significant by univariate analysis. Unadjusted mortality proportions ranged from 4.3 to 44.0%. Logistic regression analysis demonstrated that APR-mortality risk, length of stay, and discharge ward were significantly and independently associated with 30-day mortality risk in patients with CHF. In summary, 30-day mortality risk varied significantly according to the ward of discharge in an Italian teaching hospital, even after adjustment for severity of illness.

Key words: APR-mortality risk, Congestive heart failure, Mortality prediction

Introduction

In recent years, there has been an increasing interest in measuring health outcome, in particular hospital mortality, as an indicator of care quality. In US, the health care financing administration (HCFA) releases an annual report comparing actual hospital mortality rates with predicted ones [1]. In Italy, the introduction of the diagnosis related groups (DRG) prospective payment system has made computerised data sets available which now allow hospital mortality rates to be used as an outcome indicator and a hospital quality index [2–4]. For a valid inter-hospital comparison, death rates need to be adjusted for the severity of illness experienced by the patient [3–7]. Several severity measures are available for this purpose. Some, including medisgroup, and physiology score, use clinical information. Others, such as disease staging, patient management categories severity score (PMCs), and all patient refined diagnosis related group (APR-DRG) [8–11] use code-based information.

Congestive heart failure (CHF) was chosen as the focus of this study, because it represents an important public health problem which accounts for significant resource utilisation [12]. According to the Italian Health Minister [13], CHF was one of the top 10 discharge DRGs diagnoses in 1996, a year during which 127,043 cases were counted with an average hospital stay of 10.7 days. With the ageing of the population, the number may increase.

The object of this study was to assess the risk of mortality in patients with CHF admitted to different wards of an Italian teaching hospital and to determine relevant factors predictive of mortality.

Methods

The study was conducted at the Azienda Ospedaliera Senese, the teaching hospital of Siena, in Italy. The Azienda Ospedaliera Senese is the referral centre for the Southern Tuscany area (1997 population: 780,000) for high speciality admissions and, for the immediate Sienese area (1997 population: 134,000) for routine admissions. In 1997, its bed number was 1194. Study data were obtained from discharge files of all consecutive admissions of CHF (DRG 127) occurred between 1997 January 1, and 1997 November 30 in the Azienda Ospedaliera Senese. Only wards with more than 20 patients were included in the analysis. Readmissions within 1 month were not included in the study. The final study population included 600 admissions (316 males and 284 females) who were resident in Tuscany, had a minimum age of 40 years and were discharged from one of the 10 different wards of this hospital.

A 30-day post-admission mortality was calculated by cross-linking (key link: name and date of birth) hospital discharge files with the Tuscany mortality registry (TMR) database (administered by the Centre of Cancer Study and Prevention, CSPO, Florence). The linkage process was developed in two steps. After first linking the date of birth and the full name of the patient, secondary links (semi-automated) were established between the patient's full name and the year of birth, between the first 10 characters of the name and the date of birth and between the first 10 characters of the name and the year of birth.

The participation to a feasibility project aimed at evaluating the APR-DRG logic on the basis of administrative data supplied by 15 Italian hospitals made the logic and the software available for this study [14]. The 3M APR-DRG (Release 12.0) software was used to score the severity of illness experienced by the patient [15]. This software uses data from hospital discharge abstracts, including the main diagnosis, secondary diagnoses, procedures, age, sex, and post-discharge conditions as defined by the international classification of disease, 9th revision, clinical modification (ICD-9-CM). Illness severity class is divided into four levels (from 1 to 4, with 4 being the most severe) within adjacent DRGs which are subsequently used for the analysis of the cost and length of stay. The APR-DRG software considers also the risk of mortality class dividing it into four levels (from 1 to 4, with 4 representing those at highest risk of death) which are used for the mortality analyses. The severity and mortality class are determined separately based on secondary diagnoses and their interaction with age, main diagnosis and selected procedures.

Descriptive statistics were calculated for each variable. Univariate analysis was performed to evaluate the risk of death and its relationship to the following variables: APR-severity risk, APR-mortality risk, age ($\leqslant 70$ and $\geqslant 71$ years), sex, length of stay and discharge ward. Subsequently, a multivariate analysis was performed to verify the association between death (dependent variable) and discharge ward (ward No. 10 was used as a reference because it presented the largest number of admissions), APR mortality risk, and length of stay (as a continuous variable). Due to the purpose of our study, and also to the high correlation similarity between the APR-DRG severity of illness and mortality risk variables, we decided to use only the APR-DRG mortality risk in the logistic regression model.

All data were analysed using SPSS for Windows, Version 9.0.

Results

The result of linkage operations was evaluated for in-hospital deaths and it showed a 79.7% of successful linkage.

Out of the total sample of 600 admissions, there were 103 deaths within 30 days of admission.

Table 1 shows the number of patients, mean age, mean length of stay per ward, in-hospital and 30-day mortality per ward, the number and percentage of admissions per ward by APR-severity risk and APR-mortality risk level and observed mortality per ward by APR-mortality risk level.

The mean unadjusted 30-day mortality rate was 17.3%. Mortality ranged from 4.3% in ward 8 to 44.0% in ward 4 (Table 1). The overall in-hospital mortality was of 16.3%.

Descriptive analyses (χ^2 statistics) were done to identify the risk factors predictive of death. Significant ($p < 0.0001$) associations were found between death and APR-mortality risk, APR-severity risk, length of stay, and discharge ward (data not shown).

The association between APR-mortality risk or APR-severity risk and death showed a significant trend ($p < 0.0001$).

Using logistic regression analysis to control for length of stay, APR-mortality risk, and discharge ward, the adjusted odds of 30-day mortality in patients with CHF was higher for patients discharged from wards 1 (OR: 5.0), 3 (OR: 4.0), 4 (OR: 14.6) and 6 (OR: 19.5) relative to those discharged from ward 10 (Table 2). The risk of death for patients in the APR-mortality level 2 was 5-fold higher than the risk in APR level 1 ($p < 0.0001$); patients in levels 3 and 4 had respectively a risk of death 51- to 55-fold higher than patients in level 1 ($p < 0.0001$). A longer length of stay also decreased the risk of death ($p < 0.0001$) of 10% for each day of stay in the wards.

Further, because of the quite low percentage of successful linkage found for in-hospital deaths, we analysed the distribution of in-hospital deceased patients not linked with mortality files by ward for evaluating a possible selection bias. However, the distribution of these patients by ward was similar to those linked, and did not change the score of wards in term of mortality risk (data not shown).

Discussion

Mortality data are currently used as a measure of hospital performance. Nevertheless there is a large debate about the validity of mortality data [16, 17] as a true reflection of hospital quality. The availability of hospital discharge administrative databases allows us to calculate these outcome indicators.

Furthermore, there is no consensus about the source of information to be used to adjust for case-mix. The administrative databases as such, even if

Table 1. APR-DRG 127: main characteristics by wards

	Wards																			
	1	(%)	2	(%)	3	(%)	4	(%)	5	(%)	6	(%)	7	(%)	8	(%)	9	(%)	10	(%)
Number of admissions	29		94		101		50		25		20		60		23		24		174	
Mean age (±SD)	82.9 (±8.1)		69.1 (±9.5)		79.7 (±8.9)		76.0 (±12.6)		83.8 (±8.4)		80.8 (±6.6)		78.5 (±9.1)		80.1 (±9.2)		82.9 (±8.2)		79.6 (±9.7)	
Length of stay (±SD)	15.0 (±8.1)		11.4 (±9.0)		15.5 (±11.2)		17.5 (±18.4)		15.6 (±11.6)		18.6 (±19.2)		9.5 (±6.6)		12.0 (±5.8)		9.9 (±8.6)		17.0 (±12.1)	
30-day mortality																				
n	5		10		20		22		4		5		15		1		5		16	
%	17.2		10.6		19.8		44.0		16.0		25.0		25.0		4.3		20.8		9.2	
In-hospital mortality																				
n	5		10		20		22		4		5		13		1		3		15	
%	17.2		10.6		19.8		44.0		16.0		25.0		21.7		4.3		12.5		8.6	
APR severity of illness levels																				
1	6	(20.7)	36	(38.3)	35	(34.7)	14	(28.0)	9	(36.0)	12	(60.0)	21	(35.0)	9	(39.1)	6	(25.0)	55	(31.7)
2	20	(69.0)	48	(51.1)	46	(45.5)	19	(38.0)	12	(48.0)	7	(35.0)	28	(46.7)	12	(52.2)	14	(58.3)	93	(53.5)
3	3	(10.3)	8	(8.5)	20	(19.8)	13	(26.0)	2	(8.0)	1	(5.0)	11	(18.3)	2	(8.7)	4	(16.7)	25	(14.4)
4	–		2	(2.2)	–		4	(8.0)	2	(8.0)	–		–		–		–		1	(0.6)
APR-mortality risk levels																				
1	15	(51.7)	51	(54.2)	61	(60.4)	18	(36.0)	16	(64.0)	15	(75.0)	33	(55.0)	12	(52.2)	14	(58.3)	107	(61.5)
2	14	(48.3)	32	(34.0)	21	(20.8)	17	(34.0)	5	(20.0)	5	(25.0)	16	(26.7)	6	(26.0)	7	(29.2)	41	(23.6)
3	–		6	(6.4)	7	(6.9)	12	(24.0)	–		–		2	(3.3)	4	(17.4)	1	(4.2)	9	(5.2)
4	–		5	(5.3)	12	(11.9)	3	(6.0)	4	(16.0)	–		9	(15.0)	1	(4.3)	2	(8.3)	17	(9.7)
Observed mortality in APR-mortality risk levels																				
1	–		1	(2.0)	3	(4.9)	3	(16.7)	–		5	(33.3)	3	(9.1)	–		3	(21.4)	2	(1.9)
2	5	(35.7)	4	(12.5)	4	(19.0)	11	(64.7)	–		–		3	(18.7)	–		–		1	(2.4)
3	–		2	(33.3)	6	(85.8)	8	(66.7)	–		–		1	(50.0)	1	(25.0)	1	(100)	1	(11.1)
4	–		3	(60.0)	7	(58.3)	–		4	(100)	–		8	(88.9)	–		1	(50.0)	12	(70.6)

Table 2. Multivariate analysis. Adjusted ORs and 95% CI of 30-day mortality risk in patients with congestive heart failure (APR-DRG 127)

Variable	OR*	95% CI
APR-mortality risk		
1	1.0	
2	5.0	2.3–10.5
3	51.0	17.2–151.4
4	55.3	22.1–138.5
Discharge ward		
1	5.0	1.3–19.3
2	1.3	0.4–4.0
3	4.0	1.4–11.2
4	14.6	4.8–45.0
5	2.2	0.3–13.4
6	19.5	4.7–81.8
7	2.5	0.8–7.9
8	0.3	0.03–3.7
9	1.4	0.2–7.7
10	1.0	
Length of stay	0.9	0.8–0.9

*odds ratio relative to APR mortality risk level 1, discharge ward 10 and length of stay.

inexpensive and readily available, lack the clinical information necessary for risk adjustment in the prediction of hospital mortality.

The APR-severity risk adjustment software is mainly based on diagnosis interactions. It uses data from discharge abstracts to assign a level of severity of illness to each patient. In APR-DRGs, specific combinations of secondary diagnoses can interact, and these are reflected in the scores for severity of illness and for risk of mortality.

Although a variety of results in this field are available in US [18–21], in Italy, few studies are published on this subject and, in particular, on CHF [3, 4, 22].

In the present study, the performance of a predictive model for CHF death, based on APR risk adjustment in an Italian hospital administrative database was evaluated through record linkage techniques.

The linkage process highlighted problems with the recording of hospital abstracts, which were mainly caused by digit mistakes. For example, the wrong date of birth (at any level) or mistakes in the spelling of the patients' names were seen. This resulted in an estimated 20% failure in the linkage process which, however, appeared to be equally distributed by ward; furthermore, the addition of admissions not linked to the sample did not change the rank of mortality risk in the specific wards. In this study we found a quite high percentage of in-hospital and 30-day mortality (16.3 and 17.3%). These figures were much higher than the values reported by previous US studies on CHF [6, 23] but similar to those reported in other European countries [24, 25].

We found that observed mortality increased by level of APR-mortality risk. Comparing the observed death percentages in the four APR-mortality risk subgroups with the results of the Italian APR-DRG Project [14] which reports data at a national level, we found a higher proportion of deaths among classes 2 and 3 (17.1 vs. 8.8% and 48.8 vs. 19.1%) and a low percentage in class 4 (66.0 vs. 80.6%, based on very small numbers).

A predictor of mortality for CHF was the discharge ward, even after adjustment for APR-mortality risk and for length of stay. Adjustment for APR-mortality risk should account for differences in severity of the disease at admission. However, a residual confounding by severity of disease can be due to the imprecision of clinical definition. Further, because of the small sample examined, additional analyses on a bigger sample could give more stable estimates. After taking into account these limitations, differences among wards can be related with real differences in the process of care.

Furthermore, the adjustment for mortality risk performed in this study does not exclude the possibility that another detailed clinical parameter could provide a better means for stratification. The current study has the important advantage of providing a new means to evaluate hospital quality in Italy that is, by using already available mortality data. In fact, since DRGs system was introduced, very few studies [26] have been published in Italy concerning hospital mortality variation.

We think that this classification severity system based on discharge abstract has several potentialities in evaluating hospital outcome: it is easily used and it has lower costs than information derived from clinical records. In this intra-hospital comparative study, APR-DRG system let us find outcome variables in different medical wards treating CHF to be analysed in a different step. A further step of the research following this intra-hospital evaluation could be the use of this severity system for an inter-hospital comparison.

The aim of this descriptive study is the evaluation of hospital quality in the field of CHF. The variation found on outcomes can be due to admission policy, diagnosis accuracy and to management quality of patients suspected of being affected by heart failure by the individual medical staff. Their individual contribution to the observed variability needs to be carefully evaluated through a detailed monitoring.

References

1. Health Care Financing Administration. Medicare hospital mortality information 1986, 1987, 1988. HCFA Pub. No. 00647. Washington, DC: US Government Printing Office, 1989.
2. Iezzoni L. Assessing quality using administrative data. Ann Intern Med 1997; 127: 666–674.
3. Nante N, Giannuzzi P, Sapia A, Pellegrino P, Isoardi MA, Melli F, et al. Mortalità intraospedaliera DRG specifica: performances di alcuni nosocomi dell'Italia

centro-settentrionale (In-hospital mortality DRG related: Performance of different Italian northern hospitals) Annali di Igiene, X, 4 (suppl.2 – Atti 38° Congr.Naz.S.It.I.), 1998: 25.
4. Nante N, Moirano F, Giusti E, Galanti C, Giuliano G, Taddei M, et al. Mortalità intra ospedaliera DRG specifica in alcuni nosocomi italiani (In-hospital mortality DRG related in different Italian hospitals). Organizzazione Sanitaria 1999; 4: 78–91.
5. Rosenthal GE, Harper DL, Quinn LM, Cooper GS. Severity adjusted mortality and length of stay in teaching and nonteaching hospitals. Results of a regional study. JAMA 1997; 278: 485–490.
6. Rosenthal GE, Shah A, Way LE, Harper DL. Variations in standardized hospital mortality rates for six common medical diagnoses: Implications for profiling hospital quality. Med Care 1998; 36: 955–964.
7. Pine M, Norusis M, Jones B, Rosenthal GE. Predictions of hospital mortality rates: A comparison of data sources. Ann Intern Med 1997; 126: 347–354.
8. Young WW, Kohler S, Kowalski J. PMC patient severity scale: Derivation and validation. Health Serv Res 1994; 29: 367–390.
9. Iezzoni L, Moskowitz MA. A clinical assessment of medisgroup. JAMA 1988; 260: 3159–3163.
10. Gonnella JS, Hornbrook MC, Louis DZ. Staging of disease: A case-mix measurement. JAMA 1984; 251: 637–644.
11. Fridlin C. Using severity-adjusted data to impact clinical pathways. Healthc Inf Manage 1996; 10: 23–30.
12. Bilora F, Vettore G, Saccaro G, Barbata A, Dei Rossi C, Petrobelli F. Epidemiologic evaluation of cardiac decompensation and its impact on health cost. Minerva Cardioangiol 1998; 46: 235–239.
13. Ministero della Sanità. Primi 30 D.R.G. per numerosità delle dimissioni. Anno 1996 (versione D.R.G. 10) – Ricoveri per acuti – Regime ordinario. Italian Health Ministry. The largest 30 DRGs according to hospital discharges during 1996. Available at: URL:http://www.sanita.it/sdo/dati96/dc9605.htm. Accessed 18 September 2000.
14. 3M Health Information Systems. Progetto di valutazione degli APR-DRG su dati di attività ospedaliera italiana (The Italian APR-DRG project). Milano, 1999.
15. All Patient Refined Diagnosis Related Groups Definition Manual. Wallingford CT, 3M Health information systems, 1995.
16. Thomas JW, Hofer TP. Accuracy of risk-adjusted mortality rate as a measure of hospital quality of care. Med Care 1999; 37: 83–92.
17. Dubois RW, Rogers WH, Moxley JH, Draper D, Brook RH. Hospital inpatient mortality: Is it a predictor of quality? N Engl J Med 1987; 317: 1674–1680.
18. Iezzoni LI, Ash AS, Shwartz M, Landon BE, Mackiernan YD. Predicting in-hospital deaths from coronary artery bypass graft surgery: Do different severity measures give different predictions? Med Care 1998; 36: 28–39.
19. Alemi F, Rice J, Hankins R. Predicting in-hospital survival of myocardial infarction: A comparative study of various severity measures. Med Care 1990; 28: 762–775.
20. Iezzoni LI, Shwartz M, Ash AS, Mackiernan YD. Using severity measures to predict the likelihood of death for pneumonia inpatients. J Gen Intern Med 1996; 11: 23–31.
21. Localio AR, Hamory BH, Sharp TJ, Weaver SL, TenHave TR, Landis JR. Comparing hospital mortality in adult patients with pneumonia: A case study of statistical methods in a managed care program. Ann Intern Med 1995; 122: 125–132.
22. Spirito R, Musumeci S, Parolari A, Porqueddu M, Dainese L, Agrifoglio M, et al. Surgery of the ascending aorta: The 1984–1995 experience of the cardiac surgery teaching unit in the University of Milan. Multivariate analysis of its risk factors for hospital mortality and reduced long-term survival. G Ital Cardiol 1997; 27: 775–785.
23. Polanczyk CA, Rohde LE, Philbin EA, Di Salvo TG. A new casemix adjustment index for hospital mortality among patients with congestive heart failure. Med Care 1998; 36: 1489–1499.
24. McMurray J, McDonagh T, Morrison CE, Dargie HJ. Trends in hospitalization for heart failure in Scotland 1980–1990. Eur Heart 1993; 14: 1158–1162.
25. Reitsma JB, Mosterd A, de Craen AJ, Koster RW, van Cappelle FJ, Grobbee DE, et al. Increase in hospital admission rates for heart failure in The Netherlands, 1980–1993. Heart 1996; 76: 388–392.
26. Characteristics of hospitalization of aged patients before and after introduction of the prospective payment (DRG-ROD system). Researchers of the Italian Group of Pharmaco-epidemiology in the Aged. Ann Ital Med Int 1996; 11: 220–227.

Address for correspondence: Dott. De Marco Francesca, Istituto di Igiene, Università di Siena, Via Aldo Moro, Loc. S. Miniato-53100 Siena – Italy
Phone: +39 0577 234084/585892; Fax: +39 0577 234090
E-mail: demarco@unisi.it