EUROPEAN COMMISSION

Directorate-General for Health & Consumers

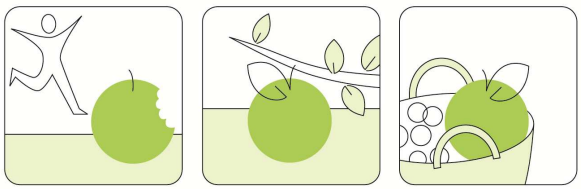
EU Public Health Outcome Research and Indicators Collection
EUPHORIC Project
Grant Agreement n°2003134

A project funded by the European Commission, Directorate General for "Health and Consumers"

Deliverable N. 12.4

Identifying the clinical variables determining the difference in terms of comparative evaluation of outcomes between register-based or information system-based risk adjustment models

January 2009 First release



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Acknowledgment: The authors would like to thank Marina Torre (partner ISS), Jaume Marrugat (partner IMAS) for their comments.

Background

Health care outcomes are often used to compare the quality of care across institutions and among individual providers. However, comparisons between hospitals could not be accurate if using risk adjustment models only based on hospital discharge records information. Predictive models based on both hospital information system data and clinical variables representing disease severity could explain most of the variability in health care outcomes under study.

Some studies have evaluated whether the addition of clinical factors to administrative data improved the accuracy of risk adjustment. Objective of our study was to assess if a AMI-specific predictive model based on administrative data (age, gender, comorbidities) plus 3 readily accessible clinical variables, and a hip fracture predictive model based on administrative data (age, gender, comorbidities) plus 2 additional clinical variables had better adaptation and performance than corresponding models only based on administrative data, and if adding these clinical variables to hospital administrative data might improve the risk adjustment for interhospital comparisons of AMI/hip fracture outcome rates.

Acute Myocardial Infarction cohort

Methods

A cohort of 3730 events of Acute Myocardial Infarction (AMI) was selected. The outcome of interest was in-hospital mortality within 30 days from the first hospital admission (index admission) for an AMI episode.

Patient comorbidities potentially associated with the outcome under study were chosen among the conditions identified in literature and those empirically tested in the Mattoni-outcome project funded by the Italian Ministry of Health (www.mattoni.ministerosalute.it). For the list of comorbidities see Deliverable “Extended protocols”.

Clinical risk factors potentially associated with the outcome were chosen among the clinical variables identified in literature and those collected in the Euphoric Cardiovascular pilot (see Deliverable “Extended protocols”). We identified three clinical variables, namely “first Ejection Fraction during hospital admission”, “creatinine (first measurement within 24 hours of admission)”, “systolic blood pressure at admission” that have shown to be risk factors for death in myocardial infarction. Based on experience in Euphoric and Mattoni-

Outcome projects and IN-ACS (Italian Network on Acute Coronary Syndromes)-Outcome registry, hospital information flow has recently been modified for the myocardial infarction in Lazio region, by adding those three variables. The modified information flow is called RAD-ESITO.

All potential risk factors from the current Hospital Information System (HIS) were retrieved using the discharge diagnoses of the index admission and previous hospital admissions during the last 24 months. Clinical variables in the index admission were retrieved from the RAD-ESITO.

We constructed two different predictive models, the first including all risk factors identified from the current hospital information system (*administrative model*) and the second including administrative data plus 3 clinical variables. Among all factors potentially associated with the outcome under study, age and gender were considered as *a priori* risk factors; the others were selected by a stepwise procedure (significance level for entry of 0.10 and for stay of 0.05). In the predictive models each comorbidity was splitted in condition registered during the index hospitalization and previous hospital admissions.

We used Akaike Information Criterion (AIC) and Receiver-operating characteristic (ROC) curves to select the best predictive model.

Akaike Information Criterion (AIC) is the most commonly adopted criterion used to compare models. The AIC is used to measure the degree of adaptation of the models to data under study, considering the number of factors included in the models. The greater the number of factors the more penalized AIC is. Low values of the AIC indicate good adaptation of the model and the model with the smallest AIC is considered the best, although the AIC value itself is not meaningful.

Receiver Operating Characteristic curve, also known as ROC curve, is a graphical representation of the tradeoff between Type-I (Sensitivity) error and Type-II (Specificity) error for different possible cutoffs and is often used to compare predictive performance between different models. A model with perfect performance has an area under ROC curve equal to 1 and higher values indicate a better ability to discriminate, that is a higher ability to distinguish subjects having the outcome from others who do not.

Once the predictive models were constructed, the adjusted 30-day mortality risks by hospital of treatment were estimated by direct standardization procedures. A logistic regression was used to estimate 30-day in-hospital mortality by hospital. With the direct adjustment method, in addition to the risk factors considered, “dummy” variables representing hospitals were added to the predictive models. The risk-adjusted mortality rate

of each hospital was compared to the mortality of the best performing hospitals (hospitals experimenting the lowest adjusted 30-day mortality).

The best performing hospitals were defined by the following steps:

1. hospital dummies were added to the models and the corresponding adjusted ORs were estimated. At this step the hospital with the highest number of AMI episodes was chosen as reference category.
2. After ranking all hospitals by adjusted ORs, the 6 hospitals with the lowest adjusted ORs were selected as the reference group.

The statistical analysis was performed using SAS Version 8.02.

Results

Table 1 shows the OR estimates for the risk factors retrieved using the current hospital information system, their 95% confidence intervals and statistical significance (p value).

The predictive model obtained included malignant neoplasms, lipid metabolism disturbances, blood disorders, hypertension, previous myocardial infarction, heart failure, chronic obstructive pulmonary disease (COPD), previous coronary artery bypass graft.

The predictive model obtained by using both variables from the current HIS and the additional clinical variables - creatinine, first Ejection Fraction (<30, 30-50,>50) and systolic blood pressure at admission- from the RAD-Esito (table 2), showed lower value of AIC and higher value of area under ROC curve (87% vs 82%). We found that 30-day mortality risk was particularly high in patients with an Ejection Fraction < 30 (OR: 16.7; p: 0.000), creatinine >1.5 (OR: 3.8; p: 0.001) and systolic blood pressure at admission ≤ 100 mmHg (OR: 3.4; p: 0.000).

Table 3 shows the adjusted OR estimates by hospital of treatment obtained using the current hospital information system or the combination of the current HIS and the RAD-Esito, their 95% confidence intervals and statistical significance (p value). The OR estimates obtained using the predictive model that included also the clinical variables were generally higher than those obtained using the model that included only patient comorbidities.

Conclusion

In our study we compared 2 predictive models for 30-day mortality rates after admission for acute myocardial infarction (AMI): (1) administrative model (age, gender and comorbidities); (2) clinical-augmented administrative model (administrative data plus 3

clinical variables, chosen among those identified in literature as risk factors for death after myocardial infarction: creatinine, first Ejection Fraction and systolic blood pressure at admission).

The 3 clinical variables have shown to be strong predictors of the 30-day mortality risk after AMI. Moreover, addition of these readily accessible clinical variables to administrative data seems to improve the risk adjustment for interhospital comparisons of AMI mortality rates.

However, further studies are needed to confirm our results in other settings or to evaluate which other clinical variables can determine the difference in terms of comparative evaluation of outcomes between register-based or information system-based risk adjustment models.

Table 1. AMI Mortality. Predictive model: current HIS

Risk factor	OR	CI 95%		p
Gender (M vs F)	0.98	0.76	1.26	0.862
Age	1.08	1.07	1.10	0.000
Malignant neoplasms	1.64	1.07	2.50	0.023
Lipid metabolism disturbances	1.28	0.65	2.54	0.481
Lipid metabolism disturbances (ind. adm)	0.24	0.12	0.49	0.000
Blood disorders	1.37	0.79	2.38	0.259
Blood disorders (ind. adm)	0.53	0.30	0.94	0.029
Hypertension	0.85	0.60	1.19	0.345
Hypertension (ind. adm)	0.27	0.20	0.37	0.000
Previous myocardial infarction	0.49	0.32	0.73	0.001
Heart failure	1.82	1.18	2.78	0.006
Chronic obstructive pulmonary disease (COPD)	1.12	0.70	1.79	0.635
COPD (ind. adm)	0.52	0.31	0.88	0.015
Previous CABG	0.34	0.12	0.95	0.039

Table 2. AMI Mortality. Predictive model: current HIS+RAD-ESITO

Risk factor	OR	CI 95%		p
Gender (M vs F)	0.96	0.74	1.24	0.750
Age	1.08	1.07	1.09	0.000
Malignant neoplasms	1.75	1.14	2.69	0.011
Lipid metabolism disturbances	1.12	0.55	2.24	0.759
Lipid metabolism disturbances (ind. adm)	0.24	0.12	0.49	0.000
Blood disorders	1.36	0.78	2.38	0.283
Blood disorders (ind. adm)	0.51	0.29	0.90	0.020
Hypertension	0.87	0.62	1.23	0.441
Hypertension (ind. adm)	0.30	0.22	0.41	0.000
Previous myocardial infarction	0.51	0.33	0.77	0.001
Heart failure	1.71	1.10	2.66	0.017
COPD	1.07	0.66	1.73	0.796
COPD (ind. adm)	0.53	0.31	0.90	0.018
Previous CABG	0.34	0.12	0.96	0.041
Creatinine >1.5	3.80	1.74	8.30	0.001
Ejection Fraction				
<30	16.68	4.86	57.19	0.000
30-50	4.34	1.26	14.90	0.020
>50	1.00			
Systolic blood pressure at admission				
missing data	1.00	0.60	1.65	0.991
<=100	3.35	2.46	4.56	0.000
>100	1.00			

Table 3. AMI mortality. Adjusted ORs calculated by using the current HIS and the RAD-Esito, by hospital of treatment

Hospital of	HIS				HIS+RAD-ESITO			
treatment	OR	CI 95%		p	OR	CI 95%		p
026	1.15	0.49	2.68	0.746	1.21	0.52	2.82	0.663
218	1.33	0.44	4.04	0.611	1.45	0.48	4.39	0.512
998	1.51	0.91	2.49	0.108	1.43	0.86	2.37	0.164
076	1.55	0.74	3.23	0.247	1.50	0.72	3.16	0.280
061	1.61	0.81	3.18	0.173	1.49	0.75	2.98	0.257
902	1.61	0.50	5.14	0.423	1.67	0.52	5.33	0.385
919	1.81	0.71	4.61	0.215	1.83	0.72	4.67	0.207
905	1.83	0.69	4.83	0.221	1.45	0.54	3.89	0.466
901	1.88	0.77	4.59	0.164	1.93	0.79	4.73	0.148
271	2.02	1.07	3.80	0.029	2.04	1.08	3.86	0.028
043	2.17	0.88	5.33	0.092	2.22	0.90	5.46	0.083
215	2.36	1.01	5.51	0.047	2.43	1.04	5.67	0.040
267	2.44	1.30	4.58	0.006	2.46	1.31	4.62	0.005
071	2.50	1.02	6.09	0.044	2.53	1.03	6.21	0.043
906	2.65	1.17	6.00	0.019	2.66	1.18	6.00	0.019
044	2.68	1.20	5.98	0.016	2.34	1.05	5.26	0.039
066	2.79	1.40	5.54	0.003	2.88	1.45	5.72	0.003
180	2.85	1.34	6.09	0.007	3.06	1.43	6.54	0.004
047	2.92	1.11	7.67	0.030	3.10	1.18	8.18	0.022
206	2.98	1.49	5.97	0.002	2.67	1.33	5.36	0.006
053	3.00	1.32	6.81	0.009	3.03	1.33	6.90	0.008
165	3.07	1.42	6.65	0.004	3.13	1.44	6.78	0.004
045	3.32	1.68	6.57	0.001	3.52	1.78	6.98	0.000

Hip fracture cohort

Methods

A cohort of 3025 events of hip fracture was selected. The outcome of interest was intervention within 48 hours of hospital admission (index admission) for a hip fracture episode.

Patient comorbidities potentially associated with the outcome under study were chosen among the conditions identified in literature and those empirically tested in the Mattoni-outcome project funded by the Italian Ministry of Health (www.mattoni.ministerosalute.it). For the list of comorbidities see Deliverable “Extended protocols”.

Clinical risk factors potentially associated with the outcome were chosen among the clinical variables identified in literature. We identified two clinical variables, namely “INR (International Normalised Ratio)” and “creatinine (first measurement within 24 hours of admission)”, that have shown to be risk factors for intervention after hip fracture. Based on experience in Mattoni-Outcome project, hospital information flow has recently been modified for the hip fracture hospitalisations in Lazio region, by adding those two variables. The modified information flow is called RAD-ESITO.

All potential risk factors from the current Hospital Information System (HIS) were retrieved using the discharge diagnoses of the index admission and previous hospital admissions during the last 24 months. Clinical variables in the index admission were retrieved from the RAD-ESITO.

We constructed two different predictive models, the first including all risk factors identified from the current hospital information system (*administrative model*) and the second including administrative data plus 2 clinical variables. Among all factors potentially associated with the outcome under study, age and gender were considered as *a priori* risk factors; the others were selected by a stepwise procedure as explained in the AMI cohort section. In the predictive models each comorbidity was splitted in condition registered during the index hospitalization and previous hospital admissions.

We used Akaike Information Criterion (AIC) and Receiver-operating characteristic (ROC) curves to select the best predictive model (see the AMI cohort section for further details).

The statistical analysis was performed using SAS Version 8.02.

Results

Table 4 shows the OR estimates for the risk factors retrieved using the current hospital information system, their 95% confidence intervals and statistical significance (p value). The predictive model obtained included diabetes, hypertension, other forms of ischemic heart disease, and blood disorders (from both the index and previous hospitalisations).

The predictive model obtained by using both variables from the current HIS and the additional clinical variables – INR (<0.8, 0.8-1.2, 1.2-2.0, >2.0), and creatinine (<1.4, >=1.4) - from the RAD-Esito (table 5), showed lower value of AIC and higher value of area under ROC. We found that 2-day intervention risk was particularly low in patients with mid-to-high INR (1.2 to 2.0; OR: 0.77; p: 0.024) but not in those with highest INR values (>2.0; OR: 0.84; p: 0.594). Also creatinine >1.4 (OR: 1.13; p: 0.221) was an important predictor of intervention, though not statistically significant.

Conclusion

In our study we compared 2 predictive models for 2-day intervention rates after admission for hip fracture: (1) administrative model (age, gender and comorbidities); (2) clinical-augmented administrative model (administrative data plus 2 clinical variables, chosen among those identified in literature as risk factors for intervention after hip fracture: INR and creatinine).

The 2 clinical variables have shown to be important predictors of the 2-day intervention risk after hip fracture. However, further studies are needed to confirm our results in other settings or to evaluate which other clinical variables can determine the difference in terms of comparative evaluation of outcomes between register-based or information system-based risk adjustment models.

Table 4. Hip fracture 2-day intervention rates. Predictive model: current HIS

Risk factor	OR	95% CI		p
Gender (F vs M)	1.13	0.97	1.32	0.127
Age	1.00	0.99	1.00	0.245
Diabetes	0.62	0.46	0.83	0.001
Hypertension	1.27	1.05	1.53	0.015
Other forms of chronic ischemic heart disease	0.69	0.55	0.88	0.002
Blood disorders (ind. adm)	1.43	1.23	1.67	0.000
Blood disorders	0.80	0.59	1.09	0.160

Table 5. Hip fracture intervention rates. Predictive model: current HIS+RAD-ESITO

Risk factor		OR	95%CI		p
Gender (F vs M)		1.04	0.85	1.26	0.702
Age		0.99	0.98	1.00	0.131
Diabetes		0.79	0.54	1.16	0.227
Hypertension		1.18	0.93	1.50	0.179
Other forms of chronic ischemic heart disease		0.77	0.57	1.04	0.091
Blood disorders (ind. adm)		1.13	0.94	1.37	0.188
Blood disorders		0.90	0.61	1.31	0.573
INR	<0.8	1.17	0.55	2.49	0.678
	0.8-1.2	1.00			
	1.2-2	0.77	0.61	0.97	0.024
	>2	0.84	0.43	1.62	0.594
Creatinine	>1.4	1.13	0.93	1.37	0.221
	<=1.4	1.00			

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