ERJ Express. Published on October 19, 2009 as doi: 10.1183/09031936.00056209

Profiling hospital performance to monitor the quality of care: the case of Chronic Obstructive Pulmonary Disease

Short title: Quality of care for hospitalized COPD patients

Word count:	**Abstract:**	**200**
	Text:	**3344**
	Online Appendix:	**707**

Authors:

Nera Agabiti, Valeria Belleudi, Marina Davoli, Francesco Forastiere, Annunziata Faustini, Riccardo Pistelli*, Danilo Fusco, Carlo A. Perucci.

Epidemiology Department Local Health Authority ASL RM/E Rome; * Respiratory Department Catholic University Rome - Italy

Contact:

Nera Agabiti, MD

Epidemiology Department

Local Health Authority ASL RM/E

Via di S.Costanza 53

00198 Roma

Tel 39-6-83060402

Fax: 06-83060374

e_mail: agabiti@asplazio.it

Key words: COPD exacerbation, health information systems, health outcomes, mortality, quality of care, report cards

ABSTRACT

Background

Comparative outcomes data is widely used to monitor quality of care in cardiovascular area; little is available in respiratory field. We applied validated methods to compare hospital outcomes for chronic obstructive pulmonary disease (COPD) exacerbation.

Methods

From Hospital Information System, we selected all hospital admissions for COPD exacerbation in Rome (2001-2005). Vital status within 30 days was obtained from the Municipality Mortality Register. Each hospital was compared to a pool of hospitals with the lowest adjusted mortality rate (*benchmark*). Age, gender and several potential clinical predictors were covariates in logistic regression analysis.

Results

12,756 exacerbated COPD were analysed (mean age 74 yrs, 71% men). Diabetes, hypertension, ischemic heart disease, heart failure, arrhytmia were the most common coexisting conditions. The average crude mortality in the benchmark was 3.8%; in the remaining population 7.5% (range from 5.2 to17.2%). In comparison with the *benchmark*, the relative risk (RR) of 30-day mortality varied widely across the hospitals (range from 1.5 to 5.9%).

Conclusion

A large variability in 30-day mortality after COPD exacerbation exists even considering patients' characteristics. Though these results do not detect mechanisms related to worse outcomes, they may be useful to stimulate providers to revision and improvement of COPD care management.

INTRODUCTION

In the last decades, there has been a proliferation of data on comparative performance of health care providers both in USA and in Europe, on the assumption that measuring quality of care is a key component in improving care. The best known example is the publication of the hospital report cards for cardiac surgery in the New York State since the late '80s, followed by similar programs in other countries. [1,3] The publication of hospital outcome data has become progressively more popular as an answer to society's increasing consensus on general "right to know". However there is still much debate on the actual impact. While it has been recognized that publicly releasing performance data stimulates quality improvement activity at the hospital level, the effect of public reporting on effectiveness, safety, and patient-centeredness remains uncertain. [4,5] Outcome data is proved to be useful for research and monitoring trends within an organization. However, it has been underlined that, without further analysis, these data may wrongly penalize doctors and managers and research efforts should rather focus on measures of adherence to clinical and managerial standards than comparative outcomes. [6]

While large experience exists in measuring and publishing comparative outcomes data in cardiovascular area, interest is now growing in implementing this methodology in other fields. Chronic obstructive pulmonary disease (COPD) is one of the most common causes of hospital admissions in Italy: about 100,000 patients 65+ year-old aged are hospitalized every year.[7] The health and social economic burden of COPD is serious and increasing over time, with hospitalization for acute exacerbations being the major component.[8] In-hospital mortality is high and patients experience extended lengths of stay.[7,9]. Current guidelines identify evidence-based management strategies to be implemented at hospital level to improve outcomes for exacerbated COPD patients, but little is known on their current application and on factors potentially influencing outcomes.[10] As a unique and stimulating initiative in Europe, the UK National Audit Program for acute exacerbation of COPD found wide variability in 90-day mortality unexplained by clinical factors and demonstrated an association between high quality specialized hospital care and better outcomes.[11,12].

Within the framework of a NHS programme on health care outcomes, standardized methodology to produce comparative hospital performance data for a large range of medical and surgical conditions has been developed in Italy in the recent years.[13] In the present study we compare hospitals in

term of mortality for hospitalized patients with acute COPD exacerbation by using data from the regional electronic health registries.

METHODS

Source of data

Discharge abstracts, both from public and private hospitals, are routinely collected by the Hospital Information System of the Lazio Region, where Rome is located (about 2.7 million residents). They contain patient demographic data, admission and discharge dates, up to six discharge diagnoses (International Classification of Disease, 9th revision, Clinical Modification [ICD-9-CM]), up to six clinical procedures, modality of admission (emergency vs. scheduled admission) and status at discharge (alive, dead, transferred to other hospital). The municipal registry maintains records on all official residents of Rome, including vital status and date and place of death. Individual codes allow to identify people in different datasets.

Selection of episodes of care

Overall we identified 26,370 acute episodes of care in the period 1-1-2001/30-9-2005 for 35+ year-aged residents in Rome with acute exacerbation of COPD (ICD-9-CM codes main diagnosis 490, 491, 492, 494, 496). We also included episodes with main diagnosis of acute respiratory failure (ICD-9-CM codes 518.81 or 518.82) or dyspnoea and other respiratory symptoms (ICD-9-CM codes 786.0, 786.2, 786.4) and secondary diagnosis of COPD. In case of multiple episodes in a 90-day period, we included only the first episode, assuming the subsequent admissions as clinically related. All patients were initially assessed at the Emergency Department. Those patients with secondary diagnosis of major trauma or major surgical operations during the index event were excluded. At the end of the selection procedures, there was a total of 12,756 episodes of care (index events), corresponding to 10,124 patients. Details on selection procedures and ICD-9-CM codes are in the online Appendix.

Individual characteristics

Clinical data

On the basis of ICD-9-CM codes, we identified three categories of "Acute respiratory conditions in the index event" as a proxy of severity of the COPD exacerbation: 1) acute respiratory failure, 2) dyspnoea or other respiratory symptoms, 3) other acute respiratory conditions including infections. Following the enhanced Elixhauser AHRQ-Web-ICD-9-CM coding algorithm, we defined chronic coexisting conditions (*comorbidities*) that can influence the prognosis. [14] We defined

comorbidities both in the index event and in the previous 4-year hospital admissions. In order to deal with the limit of administrative data in distinguishing present-on-admission diagnoses from other acute events potentially related with the care delivered, we adopted specific coding algorithms aimed at defining only chronic conditions, separately for the index and the previous hospital admissions. In the index hospitalisation coding algorithm, codes related to acute medical events that could be complications of care were not included in the definition of chronic comorbidities. As a proxy of severity, hospital utilization for acute COPD exacerbation in the preceding four years was also examined. For details on selection procedures and ICD-9-CM codes see the online Appendix.

Hospital characteristics

Patients were treated in 21 public hospitals (20 in the city of Rome, one outside the city but in a nearby community) admitting acute medical cases. A total of fifteen were public hospitals, three were teaching hospitals, and three were privately funded. Most of the hospitals had an Emergency Department but four. Only six hospitals had a pneumological ward.

Outcome

Vital status at the end of 30 days after the admission date was evaluated with a linkage procedure with the municipal registry. The outcome was "30-day mortality".

Statistical analysis

Age was subdivided in classes (35-64, 65-74, 75-84, 85+ years). Acute respiratory conditions in index events and previous 4-year hospitalization for COPD were dummy variables (having or not having the condition). Similarly, for each comorbidity, we created a binary variable indicating the presence, separately at the index event or in the hospitalisations in the previous 4–year period.

The analyses were conducted in steps.

First step - We performed a logistic regression analyses (Odds Ratios, OR) to develop the best predictive model for the outcome without considering hospitals. The initial variables were gender, age, acute respiratory conditions in the index event, COPD hospitalization in the previous 4-years, and chronic comorbidities. These variables were all included in the model and a backward stepwise procedure was used to discard those variables that were not associated with the outcome (p-stay=0.05 p-entry= 0.10). Comorbidities reported in the previous 4-year hospital admissions were "forced" in the models - even if not statistically significant - when the corresponding ones registered in the index admission were significant predictors of the outcome. This procedure took

partially into account the known potential biased relationship with outcomes of selected diagnoses registered in the index admissions.[15]

Second step - In order to compare hospitals, we ran a random effect logistic model (to take into account the possible effect of clustering since we considered episodes of care) including the variables resulting from step 1 and a dummy variable for each hospital. We included in the reference group (*benchmark)* the hospitals with the lowest OR. The procedure to define the benchmark was the following:

1. Twenty hospital dummies were added to the model and the corresponding adjusted ORs were estimated. At this step, the hospital with the highest number of patients was chosen as reference category.
2. After ranking all hospitals by adjusted ORs, the five hospitals with the lowest adjusted ORs were selected as the reference group. This group was selected by an iterative procedure that at each step included one hospital in the reference group. The procedure stopped when the hospital to be included in the reference group was significantly different ($p<0.10$) from the benchmark defined in the previous step. A chi square statistic was performed to quantify the global heterogeneneity between hospital in mortality rates ($p< 0.001$).

As a final step, in order to provide a meaningful summary of the results, the ORs were then transformed in Relative Risk (RRs) following the formula:

$RR = OR/(1-p0+p0*OR)$

where p0 represents mortality (percentage) in the reference group (*benchmark)*.

For each hospital, the risk-adjusted mortality rate was calculated by multiplying the average mortality in the *benchmark* by the relative risk.

Several sensitivity analyses were performed to evaluate the robustness of our results: 1) excluding all "acute respiratory conditions in the index event" from the multivariate models as potentially involved in the clinical pathway or emerged during the admission; 2) including all hospital admissions in the cohort (without the restriction to the first hospital admission in the case of multiple admissions in a 90-day period); 3) testing the effect modification by gender using an interaction term in the regression model and the likelihood ratio test under the hypothesis that the relationship between hospital and mortality varies between genders; 4) analyzing a restricted cohort of patients with acute respiratory failure to improve the specificity of case definition.

Datasets were managed and analysed using SAS 8.1. All p-values reported are two-sided.

RESULTS

Table 1 summarizes the characteristics of the study population. Data for 12,756 episodes of acute COPD exacerbations was analysed. Most were men 75+ year-old aged. About 45% reported at least one "Acute respiratory conditions in the index event". Diabetes, hypertension, ischemic heart disease, heart failure-cor polmonare, arrhythmia were the most common coexisting conditions. Prevalence of comorbidities in the previous 4-year hospitalizations tended to be lower than in the index event with the exception of other chronic heart disease, chronic digestive disease and chronic respiratory disease other than COPD. Statistically significant differences in various items were found between genders.

Table 2 shows the crude and adjusted association between several variables and 30-day mortality. Increasing age and acute respiratory conditions were significant predictors of the outcome, whilst previous 4-year hospitalizations for an acute COPD exacerbation was a protective factor. Among the comorbidities in the index event, some were strong predictors (heart failure/cor polmonare, vascular disease including cerebrovascular, chronic renal disease, neurological and muscular disorders, psychiatric disease, cancer), others had a protective effect (hypertension and thyroid disease). Similar results were obtained for comorbidities in the previous 4-year hospitalizations.

Table 3 and Figure 1 show the comparative performance of the 21 hospitals. Five hospitals were in the pooled *benchmark* (two privately funded, three without ED, three without a pneumogical ward) with a total of 1.689 episodes of care and a 30-day mortality of 3.8%. The average crude mortality in the remaining population was 7.5% (range: from 5.2% to17.2%). In comparison with the *benchmark*, the adjusted 30-day mortality varied widely across the remaining 16 hospitals (range: from RR= 1.5 in hospital n. 6 (95% CI: 0.9-2.4) to RR= 5.9 (95% CI: 3. 8-8.6) in hospital n. 21. For nine hospitals mortality was more than 2.5 fold higher than the *benchmark*. **Table 3** also shows the relative risks and the ranking order obtained from the models with exclusion of "Acute respiratory conditions in the index event including infections": the benchmark and the RRs were substantially similar to the main analysis. Interaction term for gender was not statistically significant (p value=0.92). Similar ranking order was obtained from models including all hospital admissions in the cohort. The analysis from the sub-cohort of cases with acute respiratory failure (33% of the total, mortality 12.0%) showed a large variability across hospitals as well.

DISCUSSION

We found a wide variability in 30-day mortality after acute COPD exacerbation among different hospitals in Rome. Hospitals with worse performance in the crude comparison were confirmed as "high outliers" in the adjusted analysis suggesting that heterogeneity in the case mix did not fully explain the observed differences. Other unidentified factors, such as hospital-level variables, might play an important role. The high mortality after acute COPD exacerbation is in keeping with results from previous studies where short-term mortality ranged from 2 to 14%. [9,16]

While many professional associations and governative institutions have recognized the importance of measuring quality of care, a debate is still ongoing about the role of process versus outcome indicators. On one hand guideline-based process measures are considered important means of assessing quality of care, [6] on the other hand several studies underline the potential of measuring and public reporting comparative outcome measures. [4,5] In UK, three main reasons to support policy of publishing outcome data have been suggested: to stimulate action, to promote public trust, to support patient choice.[17]. Even if rigorous evidence of the effects of public disclosure of comparative outcomes data is scanty, it has been found that the publication of health outcome data stimulates quality improvement activities at hospital level.[4] Our intent is to update this analysis periodically within the framework of a comprehensive "performance reporting system" in Lazio Region based on a regional legislation. [18] We aim to publish results and discuss them with clinicians and managers in order to promote activities of clinical and organizational audit and address problems in hospitals presenting critical results.

Despite their increasing use and acceptance, outcome report cards have their critics. The statistical methodology is fundamental: a poor validity of public report cards has a potentially devastating impact on an individual's career or a hospital's reputation .[19,20] Moreover, excluding important prognostic factors from the models may result in misclassification or mislabelling of hospital performance.[21] Recently it was found that hospital rankings may change considerably on the basis of the risk-adjustment models used and that the classification of "outlier status" depends on the chosen threshold for statistical significance. [22,23]. In our study, a less conservative approach, using $P<0.1$, could have implied more high- and low-outliers.

In UK all units admitting acute medical cases were involved in a multidisciplinary study which started in 2001. [11,12]. It represents an interesting example of a prospective audit tool at national level for routine clinical evaluation of the process and outcome of acute care for hospitalized

patients. This program showed a wide variability in standards of care for in-patients with COPD, despite the publication of management guidelines. Units with more specialists and better care had lower mortality, smaller units had worse results and patients receiving specialist care were more likely to be given interventions of proven efficacy. [11,12]. In Italy, admission to the pneumological ward was associated with better outcome in a study on COPD. [24] However, adequate resources *per se* may not be sufficient markers of quality. We hypothesize that elements of variability across hospitals in our study could be both structural–related factors (i.e. the size, the complexity of emergency department services, the presence of specialist respiratory ward, the numbers of specialists, the availability of invasive ventilation or non-invasive ventilation instruments) and of organization of care–related factors (i.e. specialist triage, integrated admission policy, access to proven-efficacy interventions like the specialist care). However, the aim of this study was to identify critical performance; exploring reasons of poor performances and testing possible different hypothesis represent next steps.

When profiling hospital performance, it is necessary to control for pre-admission predictors of the outcome. Risk adjustment is utilized to control confounding factors due to severity and comorbidity. [1,2,15]. We followed a validated methodology to define the patients' case mix. [14]. The coding comorbitidy algorithm for the index event allowed analysing only patient factors on admission or close to admission as case mix predictors excluding events potentially on the causal pathway between hospital and outcome. Even if detailed clinical data on patient's risk factors collected from chart reviews is considered the "gold standard", several comparative studies demonstrated a good correlation between risk-adjusted outcomes obtained from clinical data versus administrative datasets.[25,26] The empirical approach we used to define severity and adjust for allowed the identification and control of confounding factors according to their specific relationship with the outcome in the population. Any risk adjustment function, in fact, should be time and population specific.[27]

After adjustment for difference in case mix, hospitals treating sicker patients are reassured that they will not be penalized. [1,2,27]. In general, hospitals are compared either to an average-mortality institution or the average performance in the entire population. All hospitals need to be compared to the same *benchmark*. However there are questions about which is the most appropriate *benchmark*. [19] Moreover, the choice of *benchmark* may have potential different important implications for patients, providers, policy makers. Historically AMI report cards used indirect standardization to compare hospitals to an average performer. [2,21] However, using peer-group

defined *benchmarks* to compare hospitals sharing similar contextual and organizational characteristics might result in a better way to stimulate quality improvement among providers, whilst in the case of public reporting a comparison within peer-groups might be less relevant. [19,20]

The role of comorbidities in outcomes among COPD patients is not fully understood. Comorbidities such as cardiovascular disease and lung cancer are the leading causes of mortality in COPD patients, but the underlying mechanism of association is not clear.[8,28] Even the definition of comorbidities is problematic in COPD patients as certain coexisting illnesses may be a consequence of the patient's underlying COPD. A greater number of comorbidities are associated with in-hospital mortality in COPD patients admitted to hospitals, [8,9] among them diabetes mellitus and congestive heart failure. Our findings confirmed previous results and add information on the underlying complex mechanisms.

We found that COPD hospitalization in the previous 4 years is a protective factor. It seems a paradoxical result since other studies showed the opposite.[9] However, it needs to be considered that information on previous COPD was available only for those patients surviving at the time of study inclusion, thus introducing a potential bias in the comparison between individuals with or without past COPD exacerbation. Otherwise, previous COPD hospitalization could be considered a marker of more frequent contacts with specialist care and access to appropriate treatment like corticosteroid or long-acting bronchodilators that are associated with lower mortality.[10]

The strengths of this study are the population-based design, the numbers, the validated algorithm for variable definitions. This is the first large study in Europe comparing hospital performance in relation to mortality after acute COPD exacerbation by applying standardized methodology. The major limitation is the accuracy of ICD-9-CM coding. Unfortunately, we are not able to validate the diagnosis of COPD by evaluating clinical/functional variables and addressing the potential miscoding across hospitals. As in studies like this, we identified COPD patients by using the main diagnosis, however we cannot exclude inclusion of non-COPD patients. The gender distribution (41% females), slightly different from figures observed for national COPD prevalence (7.3% among males, 5.0% females), [29] seems to support this hypothesis. However, factors influencing hospital admissions (i.e. severity of disease, adherence to therapy, access to preventive services / primary care) have been shown to vary by gender for many conditions and may have played a role in our study. As a partial support for reliability of the adopted case definition, in a cohort study of 500

patients residents in Rome with diagnosis of COPD based on clinical data we found good correlation between severity of COPD and hospitalisation rate (data not published). As an attempt to minimize potential case-misclassification, we included only patients who were admitted through the Emergency Department. We also made furher sensitivity analyses to improve specificity of case definition, but the main result of this study was confirmed. Finally, administrative data did not allow insight into clinical or physiological factors. However, important clinical determinants of outcomes after COPD were found to explain only 15% of the variability in mortality across institutions [12] and we trust the known good performance of administrative data for studies on outcomes.[26,27]. Residual confounding bias for unmeasured factors should be considered as a potential limit of the study. [30]

In conclusion, the wide variation of mortality after COPD among hospitals, only partially explained by the clinical case mix of admitted patients, is unacceptable. Public disclosure of these results should stimulate clinicians and managers to investigate the underlining mechanisms in order to improve the quality of care. The large number of patients admitted with COPD and the high mortality justify further studies to address which aspects of the organization of care may be associated with worse outcomes in our country.

ACKNOWLEDGMENTS

Authors are grateful to Roberta Macci and Sandra Magliolo for their support in finding the cited articles.

COMPETING INTERESTS

Authors declare that they have no competing interests.

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Table 1 - Characteristics of the study population. Hospital admissions for acute exhacerbation of COPD, Rome 2001-2005.

	Men		Women		Total		
	N (7456)	**%**	**N (5300)**	**%**	**N (12756)**	**%**	
Age class (yrs)							*
35-64	1263	16,9	759	14,3	2022	15,9	
65-74	2544	34,1	1451	27,4	3995	31,3	
75-84	2832	38,0	2056	38,8	4888	38,3	
85+	817	11,0	1034	19,5	1851	14,5	
Age (yrs)							
Mean (SD)	73.3 (9.8)		75.4 (10.7)		74.2 (11.5)		
Acute respiratory conditions in the index event							
Acute respiratory failure	2539	34,1	1715	32,4	4254	33,4	*
Dispnoea or other respiratory symptoms	610	8,2	344	6,5	954	7,5	*
Acute respiratory conditions°	299	4,0	167	3,2	466	3,7	*
Previous hospitalization for acute exhacerbation of COPD (in the 4 yrs before the index event)	2872	38,5	1588	30,0	4460	35,0	*
Comorbidities in the index event							
Diabetes	1047	14,0	820	15,5	1867	14,6	*
Hypertension	2057	27,6	1777	33,5	3834	30,1	*
Ischemic Heart Disease	1175	15,8	671	12,7	1846	14,5	*
Heart failure / Cor polmonare	770	10,3	558	10,5	1328	10,4	
Other Chronic Heart Disease	346	4,6	253	4,8	599	4,7	
Arrhytmia	739	9,9	621	11,7	1360	10,7	*
Vascular disease including cerebrovascular	635	8,5	393	7,4	1028	8,1	*
Obesity and lipid metabolism disorders	280	3,8	374	7,1	654	5,1	*
Chronic Digestive Disease	164	2,2	76	1,4	240	1,9	*
Chronic Renal Disease	408	5,5	203	3,8	611	4,8	*
Neurological and muscolar disease	235	3,2	188	3,5	423	3,3	
Anemia and Coagulation Disorders	203	2,7	146	2,8	349	2,7	
Thyroid Disease	102	1,4	269	5,1	371	2,9	*
Psychiatric Disease	231	3,1	252	4,8	483	3,8	*
Chronic Respiratory Disease othen than COPD	222	3,0	139	2,6	361	2,8	
Cancer	368	4,9	145	2,7	513	4,0	*
Comorbidities in the 4 yrs before the index event							
Diabetes	766	10,3	580	10,9	1346	10,6	
Hypertension	1423	19,1	1152	21,7	2575	20,2	*
Ischemic Heart Disease	938	12,6	484	9,1	1422	11,1	*
Heart failure / Cor polmonare	734	9,8	480	9,1	1214	9,5	
Other Chronic Heart Disease	720	9,7	508	9,6	1228	9,6	
Arrhytmia	654	8,8	499	9,4	1153	9,0	
Vascular disease including cerebrovascular	704	9,4	398	7,5	1102	8,6	*
Obesity and lipid metabolism disorders	200	2,7	257	4,8	457	3,6	*
Chronic Digestive Disease	201	2,7	93	1,8	294	2,3	*
Chronic Renal Disease	220	3,0	146	2,8	366	2,9	
Neurological and muscolar disease	221	3,0	154	2,9	375	2,9	
Anemia and Coagulation Disorders	135	1,8	159	3,0	294	2,3	*
Thyroid Disease	70	0,9	205	3,9	275	2,2	*
Psychiatric Disease	185	2,5	197	3,7	382	3,0	*
Chronic Respiratory Disease othen than COPD	268	3,6	189	3,6	457	3,6	
Cancer	432	5,8	166	3,1	598	4,7	

° including: empyema, pneumothorax, pleuritis, collapse, abscess

* Chi-square statistic $p < 0.05$

Table 2 - Association of individual characteristics with 30-day mortality for patients with acute exhacerbation of COPD, Rome 2001-2005. Crude and adjusted ORs and 95% CI.

	N	30-day mortality		Crude RR	95% CI		Adjusted RR**	95% CI		
		n	%							
Gender										
Men	7456	570	7,6							
Women	5300	389	7,3	1,0	0,8	1,1	0,9	0,8	1,1	
Age class (yrs)										
35-64	2022	52	2,6							
65-74	3995	203	5,1	2,0	1,5	2,6	1,9	1,4	2,6	*
75-84	4888	404	8,3	3,2	2,4	4,2	3,0	2,3	4,0	*
85+	1851	300	16,2	6,3	4,9	8,1	6,1	4,7	7,9	*
Acute respiratory conditions in the index event										
Acute respiratory failure	4254	512	12,0	2,3	2,0	2,6	2,9	2,5	3,3	*
Dispnoea or other respiratory symptoms	954	136	14,3	2,0	1,7	2,4	3,2	2,6	3,7	*
Acute respiratory conditions°	466	54	11,6	1,6	1,2	2,0	1,1	0,8	1,5	
Previous hospitalization for acute exhacerbation of COPD (in the 4 yrs before the index event)	4460	271	6,1	0,7	0,6	0,8	0,7	0,6	0,8	*
Comorbidities in the index event										
Diabetes	1867	115	6,2	0,8	0,7	1,0				
Hypertension	3834	136	3,5	0,4	0,3	0,5	0,4	0,4	0,5	*
Ischemic Heart Disease	1846	170	9,2	1,3	1,1	1,5				
Heart failure / Cor polmonare	1328	199	15,0	2,3	2,0	2,6	1,7	1,4	2,0	*
Other Chronic Heart Disease	599	39	6,5	0,9	0,6	1,2				
Arrhytmia	1360	117	8,6	1,2	1,0	1,4				
Vascular disease including cerebrovascular	1028	120	11,7	1,6	1,4	1,9	1,3	1,1	1,6	*
Obesity and lipid metabolism disorders	654	28	4,3	0,6	0,4	0,8				
Chronic Digestive Disease	240	17	7,1	0,9	0,6	1,5				
Chronic Renal Disease	611	85	13,9	1,9	1,6	2,4	1,6	1,3	2,0	*
Neurological and muscolar disease	423	66	15,6	2,2	1,7	2,7	1,5	1,1	2,0	*
Anemia and Coagulation Disorders	349	26	7,4	1,0	0,7	1,4				
Thyroid Disease	371	3	0,8	0,1	0,0	0,3	0,1	0,0	0,4	*
Psychiatric Disease	483	62	12,8	1,8	1,4	2,2	1,5	1,1	1,9	*
Chronic Respiratory Disease othen than COPD	361	29	8,0	1,1	0,7	1,5				
Cancer	513	81	15,8	2,2	1,8	2,7	2,0	1,5	2,6	*
Comorbidities in the 4 yrs before the index event										
Diabetes	1346	111	8,2	1,1	0,9	1,3				
Hypertension	2575	161	6,3	0,8	0,7	0,9	0,9	0,8	1,1	
Ischemic Heart Disease	1422	108	7,6	1,0	0,8	1,2				
Heart failure / Cor polmonare	1214	118	9,7	1,3	1,1	1,6	1,0	0,8	1,2	
Other Chronic Heart Disease	1228	113	9,2	1,3	1,0	1,5				
Arrhytmia	1153	120	10,4	1,4	1,2	1,7	1,3	1,1	1,6	*
Vascular disease including cerebrovascular	1102	118	10,7	1,5	1,2	1,8	1,1	0,9	1,4	
Obesity and lipid metabolism disorders	457	18	3,9	0,5	0,3	0,8				
Chronic Digestive Disease	294	27	9,2	1,2	0,8	1,8	1,7	1,1	2,4	*
Chronic Renal Disease	366	45	12,3	1,7	1,3	2,2	1,1	0,8	1,5	
Neurological and muscolar disease	375	63	16,8	2,3	1,8	2,9	1,8	1,3	2,3	*
Anemia and Coagulation Disorders	294	31	10,5	1,4	1,0	2,0				
Thyroid Disease	275	20	7,3	1,0	0,6	1,5	1,2	0,7	1,8	
Psychiatric Disease	382	52	13,6	1,9	1,4	2,4	1,8	1,3	2,3	*
Chronic Respiratory Disease othen than COPD	475	32	6,7	0,9	0,6	1,2				
Cancer	598	69	11,5	1,6	1,2	2,0	1,3	0,9	1,7	

° including: empyema, pneumothorax, pleuritis, collapse, abscess

* statistically significant

**RR adjusted for all variables described in this table

Table 3 - 30-day mortality for patients with acute exhacerbation of COPD in Rome 2001-2005. Comparative performance of hospitals. RRs and 95 % CI for each hospital compared to the reference pool of hospitals (benchmark).

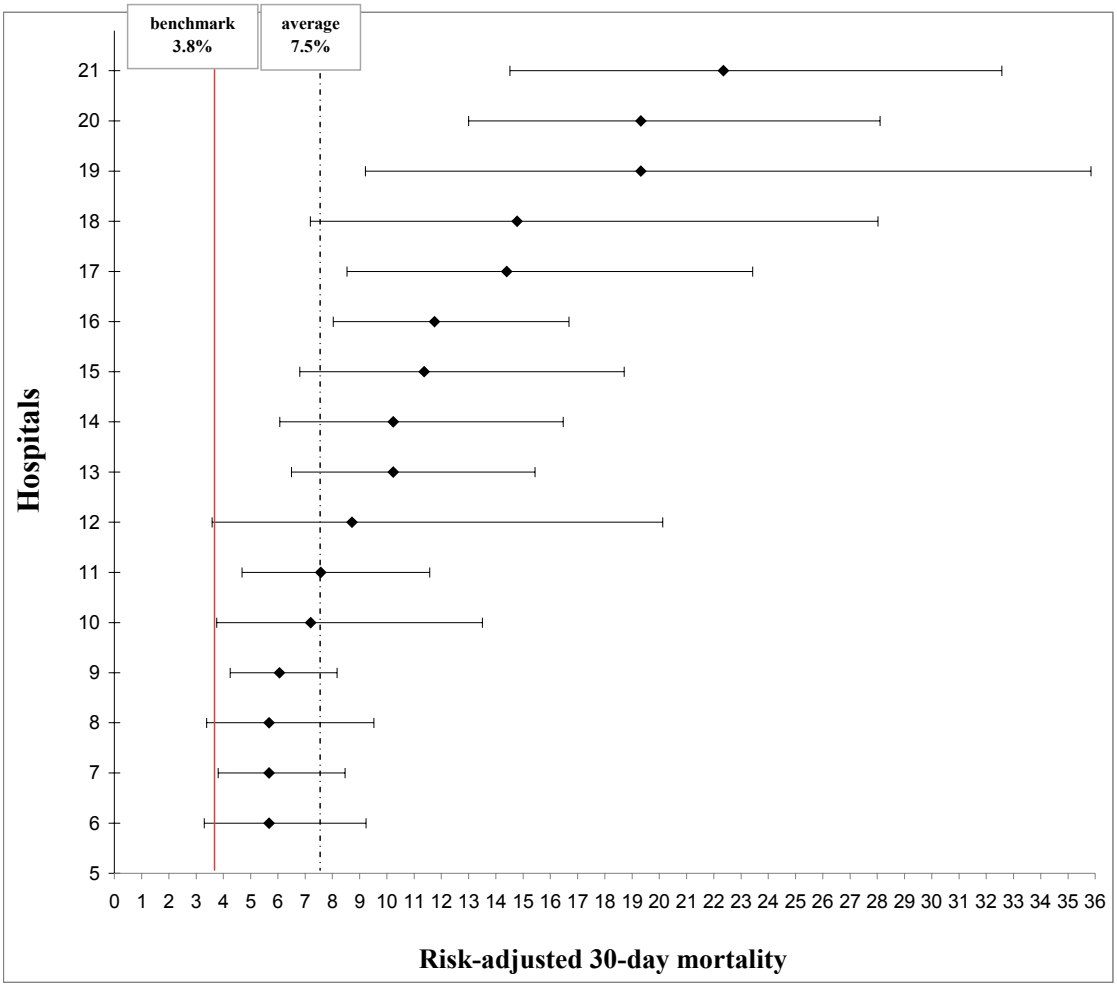
Hospital	N	30 day mortality		Crude association				Adjusted association - model 1*				Adjusted association - model 2**			
		m	%	RR	95 % CI		rank	RR	95 % CI		rank	RR	95 % CI		rank
Reference pool of hospitals															
1	369	6	1,6												
2	183	9	4,9												
3	219	5	2,3												
4	221	7	3,2												
5	697	37	5,3												
benchmark	**1689**	**64**	**3,8**	-	-	-	-	-	-	-	-	-	-	-	-
6	466	29	6,2	**1,7**	1,0	2,7	*3*	**1,5**	0,9	2,4	*1*	**1,5**	0,9	2,5	*2*
7	859	76	8,8	**2,7**	1,8	3,9	*9*	**1,5**	1,0	2,2	*2*	**2,0**	1,4	2,9	*8*
8	483	28	5,8	**1,6**	1,0	2,7	*2*	**1,5**	0,9	2,5	*3*	**1,6**	1,0	2,6	*3*
9	3678	193	5,2	**1,5**	1,1	2,0	*1*	**1,6**	1,1	2,2	*4*	**1,4**	1,1	2,0	*1*
10	213	17	8,0	**2,4**	1,3	4,4	*6*	**1,9**	1,0	3,6	*5*	**1,9**	1,0	3,5	*6*
11	542	48	8,9	**2,6**	1,7	4,0	*8*	**2,0**	1,2	3,1	*6*	**2,0**	1,3	3,0	*9*
12	103	8	7,8	**2,2**	1,0	4,9	*5*	**2,3**	0,9	5,3	*7*	**1,8**	0,8	4,0	*4*
13	717	47	6,6	**1,9**	1,2	2,8	*4*	**2,7**	1,7	4,1	*8*	**1,9**	1,3	2,9	*5*
14	379	31	8,2	**2,5**	1,5	3,9	*7*	**2,7**	1,6	4,3	*9*	**2,0**	1,2	3,2	*7*
15	298	32	10,7	**3,4**	2,1	5,3	*11*	**3,0**	1,8	4,9	*10*	**2,6**	1,6	4,1	*10*
16	940	101	10,7	**3,4**	2,3	4,7	*12*	**3,1**	2,1	4,4	*11*	**2,6**	1,8	3,7	*11*
17	251	32	12,7	**4,1**	2,5	6,4	*14*	**3,8**	2,3	6,2	*12*	**3,8**	2,3	6,0	*14*
18	108	13	12,0	**3,8**	1,9	7,2	*13*	**3,9**	1,9	7,4	*13*	**3,7**	1,8	6,8	*13*
19	110	12	10,9	**3,3**	1,6	6,4	*10*	**5,1**	2,4	9,5	*14*	**3,2**	1,6	6,2	*12*
20	491	80	16,3	**5,5**	3,7	7,8	*15*	**5,1**	3,4	7,4	*15*	**4,6**	3,1	6,6	*15*
21	389	67	17,2	**6,0**	4,0	8,7	*16*	**5,9**	3,8	8,6	*16*	**5,0**	3,3	7,3	*16*
	11716	878	7,5												
N<100	1040	81	7,8												
Tot	**12756**	**959**	**7,5**												

***** Model 1 includes all variables described in Table 2 according to the analysis described in the text

****** Model 2 includes all variables described in Table 2 excluding acute respiratory failure, dispnoea, acute respiratory conditions (see text for comment)

Note: crude and adjusted RRs are derived from the random effect models to take into account the possible effect of episode clustering by patient

Figure 1 - Risk-adjusted 30-day mortality rates (and 95% CI) across hospitals for patients with acute exhacerbation of COPD in Rome 2001-2005. References: the average mortality in the benchmark (red line) and the average mortality in the remaining population (dottet line).



Note: Risk-adjusted mortality rates (and 95% CI) are derived from random effect model - Model 1.