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Factors influencing length of hospital stay in community-acquired pneumonia: a study in 27 community hospitals

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SUMMARY

We did a retrospective study of 1920 episodes of community-acquired pneumonia (CAP) in 27 community hospitals and analysed inter-hospital variability in length of hospital stay (LOS), mortality and readmission rates. The overall adjusted LOS (mean ± S.D.) was 10·0 ± 9·8 days. LOS increased according to the Pneumonia Severity Index (PSI) risk class: 7·3 days for class I to 11·3 days for class V ($P < 0·001$). In a multiple regression model, LOS increased ($P < 0·001$) according to the hospital (inter-hospital variability), PSI risk class, complications during hospitalization, admission to ICU, need of oxygen and transfer to a nursing home. Hospitals with shorter LOS did not show an increased readmission rate (adjusted OR 1·02, 95% CI 0·51–2·03, $P = 0·97$) and post-discharge mortality (adjusted OR 1·20, 95% CI 0·70–2·05, $P = 0·51$). There are significant inter-hospital variations in LOS in patients with CAP which are related to differences in clinical management. The reduction of these differences will further improve efficiency and quality of care.

INTRODUCTION

Nowadays, the growing demands in health services and the limitation of resources require an effective hospital management. It is well known that differences in the management of patients with the same disease may affect efficiency, safety and quality of care.

Community-acquired pneumonia (CAP) is a major disease that often requires hospital admission and is one of the leading causes of hospital deaths [1–4]. There is convincing evidence that the duration of hospitalization is the most direct cost of CAP [1, 5].

Previous studies reported significant differences in the mean length of hospital stay (LOS) in patients with acute myocardial infarction and other medical conditions [6–8]. Regarding CAP, several studies have shown an inter-hospital variation in mortality [9], mean LOS [7, 10], hospital admission criteria [11, 12], and use of diagnostic and therapeutic resources [13]. However, most of these studies did not consider important clinical and epidemiological variables such as disease severity index classes, and in some of them, the information was collected from administrative databases [7].

Most recently, a multicentre study [14], including four large teaching hospitals from the United States

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and Canada, reported inter-hospital variation in mean LOS for patients suffering from CAP, but this variation did not affect the final medical outcome. Another study [15], including 20 teaching and community hospitals in Canada, showed a wide variation in LOS and the management of CAP among hospitals. The causes of this variation are not well known.

The purpose of this study was: (*a*) to describe variation in LOS after CAP between hospitals; (*b*) to identify predictors of LOS after CAP between hospitals; (*c*) to assess if this variation in LOS after CAP between hospitals is associated with outcomes such as readmission rates and post-discharge mortality.

PATIENTS AND METHODS

Setting and hospitals

This is a retrospective multicentre observational study of a representative sample of patients hospitalized with CAP in Catalonia (population 6 million), Spain, from January to December 1996. Data were collected during 1997 and 1998.

In 1996, there were 74 hospitals in Catalonia (8 tertiary high-technology hospitals and 66 community hospitals). The overall number of CAP cases (hospitalized for more than 24 h) in 1996 was over 13 000 (data obtained from the Catalan Public Health Service).

Initially, all community hospitals in Catalonia were invited to participate in the study. The basic inclusion criterion was that the hospital was using a computerized register of discharge diagnosis with an ICD9-CM codification [16].

Finally, among the 66 community hospitals, 27 (41%) participated in the study, covering a population area ranging from 12 400 to 370 000 inhabitants from urban and rural areas, with a total of about 2 500 000 inhabitants. The number of hospital beds ranged from 30 to 540, with a total of 4898 beds, representing 39% of all community hospital beds.

Ten physicians, specially trained for this study, reviewed the medical records of patients with CAP. These physicians did not belong to the staff of the hospital in which the study was being carried out. In cases of doubtful diagnosis for CAP, consensus with a coordinating physician from the hospital was required.

Definitions

CAP was considered when a patient had signs or symptoms of acute respiratory infection (e.g. cough, sputum, chest pain and fever) together with a new pulmonary infiltrate on the chest X-ray [17].

The broad study protocol incorporated many variables including demographic data, comorbid conditions, signs and symptoms, biochemical and microbiological tests, radiographic findings, LOS, treatment, complications, mortality and readmission. Other data were also recorded: history of cigarette smoking, asthma or chronic obstructive pulmonary disease, coronary artery disease, diabetes, dementia, hospitalization in the preceding year, and previous admissions for CAP. Admission to an intensive care unit (ICU), oxygen therapy, duration of intravenous antibiotic therapy, number of antibiotics, discharge destination, post-discharge mortality and readmission were also determined. LOS was defined as the date of discharge minus the date of admission.

The severity of illness for each patient was quantified using the Pneumonia Severity Index (PSI) reported by Fine et al. [18]. This index predicts short-term mortality (within 30 days) for patients with CAP by means of a score based on age, sex, nursing-home residence, several comorbid illnesses, physical examination findings, and laboratory results. According to this score, patients were categorized into five risk classes.

Overall mortality includes in-hospital mortality and 14 days' post-discharge mortality. Prior hospitalization was defined as admission to any hospital during 1 year before entry into the study. Prior pneumonia was considered when a patient had a diagnosis of CAP during the previous 2 years. Smoking was recorded when a patient had smoked more than 10 cigarettes per day for at least 1 year prior to the study.

We considered readmission when a patient was readmitted to the hospital because of an unresolved problem related to previous pneumonia. For the denominator, we used the total number of pneumonia episodes.

Microbiological data were obtained from medical charts and/or laboratory records. In 1093 out of 1920 (57%) episodes, one or more microbiological tests were performed. The most frequent microorganisms were: *Streptococcus pneumoniae* in 92 episodes (58 blood cultures, 36 sputum, 8 pleural fluid); *Pseudomonas aeruginosa* in 30 episodes (25 sputum, 5 pleural fluid); *Haemophilus influenzae* in 16 episodes (12 sputum, 2 blood cultures, 3 pleural fluid); *Staphylococcus aureus* in 10 episodes (5 sputum, 5 blood cultures, 1 pleural fluid); and *Legionella* spp. in 5 episodes (2 cultures and 3 serology).

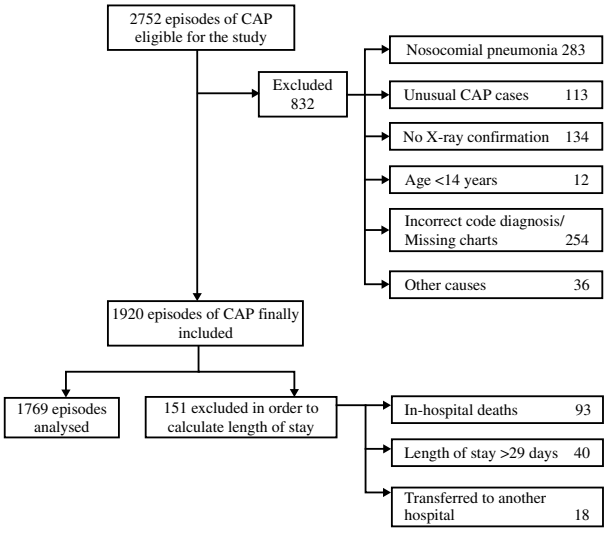

Fig. Algorithm: patients with community-acquired pneumonia (CAP) included in the study and reasons for exclusion.

Patients and study sample

From January to December 1996, the total number of hospital discharges of patients who were hospitalized with a diagnosis of CAP in the 27 hospitals was 3727. In hospitals with $\leqslant$50 cases of CAP, all cases were included, whereas in hospitals with a greater number of cases, we selected a random sample by using a systematic method. The cases of CAP were put in chronological order to get representation of all the seasonal periods in the study. Exclusions were replaced by other patients with CAP of the same age ($\pm$5 years) and sex and admission nearest to the date of the excluded case.

The adult patients (age >14 years) with a discharged diagnosis of CAP in 1996 were identified by means of the computerized diagnosis of CAP (ICD-9-CM: 480·0–487, 507·0 and 507·8). For those patients who had more than one episode of CAP, all episodes were analysed. Those cases codified as ICD9-CM = 799·9 ('unspecific or uncertain diagnosis') and DRGs = 470 ('unclassified'), which often include patients who died without a discharge report, were also reviewed. Paediatric patients (age <14 years) were excluded. Finally, 2752 episodes of CAP were eligible for the study (see Fig.).

Of the 2752 episodes, 832 (30%) were excluded due to several reasons. Briefly, hospital-acquired pneumonia (283 cases) was considered if the infection occurred 48 h after hospital admission, or if the patients came from a nursing home or had a history of prior admission to the same or another hospital in the preceding 7 days. Unusual CAP (113 cases) was considered either when the patient with pneumonia had an underlying condition such as HIV infection or haematological malignancies, or pneumonitis of non-infectious aetiology (e.g. systemic lupus erythematosus), as well as those cases in which pneumonia was considered as a 'terminal event'. Further exclusion criteria were: patients without X-ray confirmation (134 cases) due to several reasons such as a lost or not performed X-ray, no new infiltrate on the X-ray or no changes over time of the initial X-ray infiltrate; age <14 years (12 cases); missing patient's chart or incorrect discharge diagnosis or classification (254 cases) and several others (36 cases) (e.g. the patient being transferred to another hospital, tuberculosis).

Statistical analysis

Statistical analysis was carried out with the SPSS 10.1 (SPSS Inc., Chicago, IL, USA) and SAS 8.2 for Windows 2000. For numerical variables such as LOS, we used a mixed (random and fixed effects) regression model to investigate differences among the 27 hospitals, taking hospital as a random effect that is able to consider intra- and inter-hospital variability. Categorical variables were analysed by means of the χ^2 test (using $2 \times k$ categories) or Fisher's exact test when appropriate. Since the LOS did not show a normal distribution, we used the natural logarithm of this variable. Adjusted LOS was determined by multiple linear regression models after adjusting for PSI risk class, admission to an ICU, and discharge to a nursing home.

A multiple regression model was fitted to identify the influence of each hospital adjusted by other clinical and prognostic variables that could influence the LOS. We identified each hospital with an alphabetic letter in order to preserve confidentiality. The hospital with lower LOS was considered reference one category. For this analysis, patients who died during hospitalization (93 cases), patients whose mean LOS was longer than 29 days (40 cases), and those discharged to another acute hospital (18 cases) were excluded, representing a total number of 151 cases (7·9%). The remaining 1769 cases were considered for the analysis (Fig.).

In the multivariate analysis, we initially included those variables associated with LOS in the univariate analysis with a $P<0{\cdot}05$. Variables were tested

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Table 1. *Clinical and underlying conditions of 1920 patients with community-acquired pneumonia (CAP) in 27 hospitals*

		P value*
Total no. of beds (range)	4898 (30–549)	
Total no. of patients (range)	1920 (22–144)	
Age, years [mean ± S.D. (range)]	66·4 ± 18·1 (60·3–71·2)	0·132
Male sex (%)	62·3 (52·6–71·9)	0·575
Risk class I (%)	13·2 (3·1–24·6)	0·001
Risk class II (%)	17·0 (4·5–31·5)	0·001
Risk class III (%)	22·6 (13·2–36·1)	0·001
Risk class IV (%)	35·5 (18·4–53·8)	0·001
Risk class V (%)	11·7 (2·6–22·4)	0·001
No. comorbidities [mean ± S.D. (range)]	1·9 ± 1·1 (0·8–2·4)	<0·001
Asthma (%)	4·6 (0–13·2)	0·018
COPD (%)	38·1 (21·7–52·2)	0·037
CAD (%)	9·7 (0–17·2)	0·433
Diabetes mellitus (%)	15·7 (2·8–23·8)	0·031
CHF (%)	6·2 (0–19·2)	<0·001
Malignant disease (%)	2·8 (0–7·7)	0·098
Dementia (%)	6·5 (0–22·0)	<0·001
Smoking (%)	20·8 (8·0–42·9)	<0·001
Prior hospitalization (%)	21·0 (0–32·5)	<0·001
Prior CAP (%)	14·8 (0–28·5)	<0·001
Blood cultures + (%)	4·1 (0–8·0)	<0·001
Admission to ICU (%)	3·3 (0–10·7)	0·002
Days of fever [mean ± S.D. (range)]	2·3 ± 2·1 (1·4–3·8)	0·004
Days of i.v. antibiotics [mean ± S.D. (range)]	4·6 ± 3·6 (2·5–6·9)	0·001
No. of antibiotics [mean ± S.D. (range)]	1·3 ± 0·5 (1·0–1·7)	0·001
Days of O_2 therapy [mean ± S.D. (range)]	5·3 ± 5·1 (1·6–7·7)	0·001

COPD, chronic obstructive pulmonary disease; CAD, coronary artery disease; CHF, congestive heart failure.
* *P* value for inter-hospital differences.

for colineality. Some variables such as days of intravenous (i.v.) antibiotic therapy, and days of fever were not included in the final model because of colineality. The final model incorporates the following independent variables: hospital (inter-hospital variability), PSI risk class, number of complications during hospitalization, admission to an ICU, oxygen therapy and discharge to a nursing home. We did not include variables such as gender, age and comorbidities in the model since they are included in the PSI risk class [18].

In order to study the influence of LOS on post-discharge mortality and readmission, we performed multiple logistic regression models. Post-discharge mortality and readmission were the dependent variables and LOS was the independent variable, dichotomized using median overall LOS as the cut-point, adjusted for PSI risk class, number of complications during hospitalization and destination (e.g. discharge to a nursing home).

All tests were two-tailed and we defined a $P<0·05$ as statistically significant.

RESULTS

Out of 2752 reviewed episodes of CAP (in 2695 patients), 1920 (69·8%) were finally included in the study (Fig.).

Patient characteristics

The age (mean ± S.D.) of the patients was 66·4 ± 18·1 years, ranging from 60·3 to 71·2, and 62·3% of the episodes occurred in men, ranging from 52·6 to 71·9% (Table 1).

The proportion of patients belonging to each class of the PSI varied widely among hospitals. Mean and range in each PSI class were as follows: class I [13·2% (3·1–24·6%)], class II [17% (4·5–31·5%)], class III

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Table 2. *Mean length of hospital stay (LOS) in 1769 episodes of community-acquired pneumonia (CAP) stratified by risk class*

	Mean (range)	*P* value*
Risk class I	7·3 (2·5–14)	0·073
Risk class II	8·8 (4·3–12·3)	0·063
Risk class III	10·6 (5·6–16·7)	0·006
Risk class IV	10·9 (6·6–15·4)	0·002
Risk class V	11·3 (6–17)	0·101
Overall unadjusted mean	10·0 (6·3–13·7)	0·001
Overall adjusted mean†	10·0 (2·7–17·4)	0·001

This table includes 1769 episodes (out of 1920 episodes, 151 were excluded; see Fig.).
* *P* value for inter-hospital differences.
† Overall mean LOS adjusted by PSI risk class, admission to an ICU, and discharge to a nursing home.

Table 3. *Multiple regression model including those variables influencing length of hospital stay (LOS)*

	Variability	*P*	*β*
Hospital*	12·00%	<0·001	1·07–2·39
PSI risk class	7·83%	<0·001	1·10
Complications during hospitalization	5·48%	<0·001	1·12
Admission to an ICU	0·80%	<0·001	1·36
Oxygen therapy	2·56%	<0·001	1·20
Discharge to a nursing home	0·32%	0·048	1·19
Total model	28·99%	<0·001	10·0

* Inter-hospital variability.

Table 4. *Mortality during hospitalization and 14 days' post-discharge mortality and readmission rates of community-acquired pneumonia (CAP) patients*

Outcomes	Mean (range)	*P* value
Mortality during hospitalization (%)	4·8 (0–11·9)	0·012
Post-discharge mortality (%)	4·1 (0–13·0)	<0·001
Readmission (%)	2·3 (0–8·7)	0·004
Discharge to a nursing home (%)	1·0 (0–12·9)	<0·001

[22·6% (13·2–36·1%)], class IV [35·5% (18·4–53·8%)], and class V [11·7% (2·6–22·4%)].

In addition, the number of comorbidities also varied among hospitals, mean 1·9±1·1 (range from 0·8 to 2·4). Table 1 shows the most relevant comorbidities. It is significant to note that the mean duration of fever was 2·3 days (range 1·4–3·8 days). The mean duration of i.v. antibiotic therapy was 4·6 days (range 2·5–6·9 days) and the mean number of antibiotics was 1·3 (range 1·0–1·7 antibiotics). The mean duration of O_2 therapy was 5·3 days (range 1·6–7·7 days). Other variables are shown in Table 1.

LOS and outcome

The overall adjusted mean LOS was 10·0±9·8 days (range 2·7–17·4). Table 2 shows the mean LOS stratified by PSI risk class.

The mean LOS increases steadily according to PSI risk class: class I [7·3 days (range 2·5–14)], class II [8·8 days (range 4·3–12·3)], class III [10·6 days (range 5·6–16·7)], class IV [10·9 days (range 6·6–15·4)], and class V [11·3 days (range 6–17)]. Hospitals with the shortest total mean LOS usually had also the shortest mean LOS for each PSI risk class.

Table 3 shows the multiple regression analysis of factors influencing LOS.

The most important variable associated with an increased LOS was the hospital (inter-hospital variability). Likewise, severity of illness (PSI risk class), the number of complications during hospitalization, admission to an ICU, therapy with O_2, and discharge to a nursing home were also statistically significant. When we used the dependent variable of LOS (including the outliers for LOS >29 days) the results were similar (data not shown).

Table 4 shows mortality during hospitalization and after discharge, readmission rates and discharge to a nursing home.

Therefore, the overall mortality (in-hospital mortality and 14 days' post-discharge mortality) was 8·9% and differed substantially among hospitals. The proportion of readmission was 2·3% (range 0–8·7%). The proportion of discharges to a nursing home was 1% (range 0–2·9%).

As shown in Table 5, a multivariate analysis demonstrates that readmission rates and post-discharge mortality rates were not affected by variation in LOS (hospitals with short LOS did not have poorer outcomes).

Thus, after we controlled for PSI risk classes, number of complications during hospitalization, and nursing-home discharges through a logistic regression model, hospitalizations with LOS under the median of overall LOS (median=9·0 days) were not significantly associated with increased readmission rates (adjusted OR 1·02, 95% CI 0·51–2·03, *P*=0·97); and

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Table 5. *Logistic regression analysis of factors influencing readmission and mortality after discharge*

	Dependent variable: readmission*		Dependent variable: mortality after discharge†	
	Adjusted OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*
LOS above the overall median (9·0 days)	1·02 (0·51–2·03)	0·966	1·20 (0·70–2·05)	0·505
PSI risk class	1·48 (1·08–2·03)	0·014	2·30 (1·73–3·07)	<0·001
No. of complications during hospitalization	1·32 (1·01–1·72)	0·045	1·32 (1·08–1·61)	0·006
Discharge to a nursing home	6·88 (1·73–27·33)	0·006	4·80 (1·31–17·57)	0·018

* Based on 1419 patients.
† Based on 1441 patients.

post-discharge mortality (adjusted OR 1·20, 95% CI 0·70–2·05, $P=0·51$). Models using LOS as a continuous variable showed very similar results.

DISCUSSION

Inter-hospital variations in LOS for patients with the same disease can be assigned to three major categories: first, health-care systems and hospital management; secondly, physicians' practices and skills; and thirdly, patients' characteristics [6, 10, 14, 15].

In this study, we found significant variations in mean LOS for patients with CAP among the 27 community hospitals in Catalonia, Spain. These results are similar to those found in other teaching and community hospitals in the United States and Canada [15]. The mean LOS increased in association with several clinical, therapeutic and throughput variables: PSI risk classes, number of complications during hospitalization, admission to an ICU, need of oxygen therapy, and transfer to a nursing home at discharge. Moreover, after we adjusted for these variables, unexplained inter-hospital differences (variable hospital) were still detected (Table 3). These variations suggest an increase in medical care costs in hospitals with the largest LOS. Therefore, reducing inter-hospital variability will increase the cost-effectiveness of throughputs.

Our study was not designed to identify the reasons for inter-hospital variability (variable hospital) in LOS, which can be due to several factors included mainly in the categories of hospital management and clinical practice. In Table 6 we attempt to summarize the main factors that may influence LOS in patients with CAP.

It is important to emphasize that in our study as well as in others [14, 19], hospitals with the shortest LOS had no increased post-discharge mortality or higher readmission rates in patients with CAP. These data can be useful as a benchmark for physicians and hospitals in order to reduce the LOS in patients with CAP without additional risks.

Table 6. *Main factors influencing length of stay* (*LOS*) *in hospitalized patients with community-acquired pneumonia* (*CAP*)

(1) Health-care system and hospital management
Financing systems and reimbursements (e.g. managed care)
Levels of efficacy and efficiency of the hospital direction/administration
Rate of occupancy of hospital beds (e.g. lower occupancy longer LOS)
Expected discharges on weekends and holidays
Delay in performing laboratory tests or radiological exams
Health system accessibility and primary health-care support
Family and caregivers preferences and expectations for the care system
(2) Clinical practice
Physicians' skills, experience and competence
Use of good proven clinical guidelines
Early switch from i.v. to oral antibiotic therapy
Oxygen withdrawal when appropriate
Physicians' beliefs about effectiveness of health-care interventions
(3) Patient characteristics
Advanced age
Relevant comorbidities
Severity of illness (e.g. PSI risk class)
Complications or adverse events during hospitalisation
Need of supportive therapies (e.g. oxygen therapy)
Need of admission to an ICU
Need of social support (e.g. nursing homes)

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The identification of factors that increase LOS in patients with CAP (Table 6) and those factors that can be modified, is an important responsibility for physicians as well as for administrators. Currently, several useful interventions can be suggested for shortening LOS: (i) The implementation of clinical guidelines advising rapid antibiotic initiation, an appropriate antibiotic selection, an early conversion from i.v. to oral antibiotic therapy when fever disappears and an appropriate use of O_2 therapy [20–30]. (ii) Using Fine's PSI risk classes, the number of hospital admissions could be reduced by dealing with patients of class I and II in outpatient departments [31–35]. However, the significant inter-hospital differences and their possible causes (Table 6) require a more accurate evaluation in each hospital to discover the most suitable solutions.

One important question is: What is the optimal LOS in patients with CAP? It is clear that most patients with CAP improve within 3 days of hospitalization with appropriate antibiotic therapy. Then, i.v. antibiotic therapy can be switched to oral therapy. However, there may be some reasons for continuing hospitalization after the clinical condition of CAP has become stable, such as those related to comorbidities (e.g. uncontrolled diabetes), and need for social support [36]. Other possible reasons shown in Table 6 cannot be justified.

Although our study is the largest reported in the literature regarding the number of participating community hospitals and the number of patients analysed, it has some inherent limitations that should be taken into account: (1) the retrospective chart review (although it was carefully done by trained physicians), (2) the large number of patients that had to be excluded in order to have a more homogeneous group, and (3) the difficulty to define variables related to the own hospital characteristics, nurses and physicians' performance patterns, social and economic status of the patient, and primary health-care support.

LOS in our CAP study is rather long compared with LOS in most United States and Canadian hospitals. We believe this could be due to several factors (see Table 6), which may include the high number of elderly patients in our study, and because our health-care system (Spain) has a shortage of nursing homes. It is also important to know that in Spain, elderly people represent approximately 22% of the overall population compared to approximately 16–17% in the United States, Canada and Australia [37].

In conclusion, we found significant differences in mean LOS in patients with CAP that were not attributable to differences in patients' characteristics. Differences in outcomes such as post-discharge mortality and readmission between hospitals with shortest LOS and those with longest LOS were not observed. Several factors could be responsible for inter-hospital variations in LOS, most associated with medical practice and other unknown factors. Further studies are needed but steps can already be taken to reduce LOS, e.g. the implementation of clinical practice guidelines for pneumonia diagnosis and treatment [38–40].

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APPENDIX

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