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ORIGINAL ARTICLE

Predictors of drug-resistant pathogens in community-onset pneumonia: Are factors considered in health-care–associated pneumonia useful in the emergency department?

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Objectives. To analyze factors related to drug-resistant pathogens (DRPs) in community-onset pneumonia (COP) and whether previously suggested criteria are useful in our emergency-department.

Methods. Prospective 1-year study of adults coming to the emergency department for COP. We assessed the usefulness of criteria used in health-care–associated pneumonia (HCAP), as well the Shorr index, the Barthel index, and clinical suspicion of resistant pathogens. Data were analyzed by multiple logistic regression and the area under the receiver operating characteristic curve (AUC).

Results. We included 139 patients with a mean (SD) age of 75.9 (15.3) years; 63.3% were men. Forty-nine COP patients (35.2%) were at risk for DRP-caused pneumonia according to HCAP criteria; 43 (30.9%) according to the Shorr index, and 56 (40.3%) according to the Aliberti index. A score of less than 60 derived from the Barthel index was recorded for 25 patients (18%). Clinical suspicion of a DRP was recorded for 11 (7.9%). A DRP was isolated in 5 patients (3.6%) (3, *Pseudomonas aeruginosa;* 2, methicillin-resistant *Staphylococcus aureus*). Multiple logistic regression analysis identified 2 predictors of DRP-caused COP: hospital admission within the last 90 days (odds ratio [OR], 8.92; 95% CI, 1.92–41.45) and initial arterial blood oxygen saturation (OR, 0.85; 95% CI, 0.74–0.98). The AUC was 0.91 (95% CI, 0.85–0.98). The model identified 22 patients (16.8%) at risk for DRP-caused pneumonia. The positive and negative predictive values were 20% and 99.1%, respectively, for the model 90–day period (vs 8.7% and 98.9%, respectively, for criteria used in HCAP).

Conclusions. Hospitalization within the 90–day period before a COP emergency and arterial blood oxygen saturation were good predictors of DRP in our setting. Criteria of DRP in HCAP, on the other hand, had lower ability to identify patients at risk in COP.

Keywords: Pneumonia. Antibiotic resistance. Health-care–associated infection. Community-acquired infection. Hypoxia. Risk factors. Prospective study. Receiver operating characteristic curve.

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Predictores de patógenos resistentes en las neumonías procedentes de la comunidad: ¿es útil en urgencias el concepto de neumonía asociada a cuidados sanitarios?

Objetivos. Analizar en las neumonías de la comunidad diagnosticados en nuestro centro los predictores de etiología por patógenos resistentes (PR) y evaluar la utilidad de distintos criterios de riesgo de PR previamente sugeridos.

Método. Se estudiaron prospectivamente durante 1 año los pacientes adultos procedentes de la comunidad atendidos en el servicio de urgencias (SU) por neumonía. Se evaluaron los criterios definitorios de neumonía asociada al cuidado sanitario (NACS), así como los índices de Shorr, Aliberti y Barthel y el juicio clínico de PR. Se realizó regresión logística múltiple y se calculó el área bajo la curva receptor-operador (ABC-ROC).

Resultados. Se incluyeron 139 pacientes con una edad media de 75 (DE: 15,3) años, el 63,3% varones. Tenían riesgo de PR según los criterios de NACS 49 (35,2%), según el índice de Shorr 43 (30,9%) y según índice de Aliberti 56 (40,3%). Se encontró un I. Barthel < 60 en 25 enfermos (18%) y juicio clínico de PR en 11 (7,9%). Se aisló PR en el 3,6% (3 *Pseudomonas aeruginosa* y 2 *Staphylococcus aureus* meticilin resistentes). En el análisis multivariado fueron predictores de PR el haber ingresado en los 90 días previos, con una *odds ratio* (OR) de 8,92 [intervalo de confianza (IC) 95%: 1,92-41,45], y la saturación inicial de oxígeno, con una OR de 0,85 [IC 95%: 0,74-0,98] con ABC-ROC de 0,91 (IC 95%: 0,85-0,98). Nuestro modelo identificó 22 pacientes (16,8%) con riesgo de PR, con valor predictivo positivo y negativo del 20% y 99,1%, respectivamente, frente a un 8,7% y 98,9%, respectivamente para NACS.

Conclusiones. En las neumonías de nuestro centro el antecedente de ingreso en los 90 días previos junto con la saturación de oxígeno fueron buenos predictores de PR, mientras que los criterios de NACS tuvieron menor capacidad de discriminación.

Palabras clave: Neumonía. Resistencia antibiótica. Infecciones asociadas al cuidado sanitario. Infecciones adquiridas en la comunidad. Hipoxia. Factores de riesgo. Estudios prospectivos. Curvas ROC.

Introduction

The 2005 update of the clinical practice guidelines on pneumonia of the American Thoracic Society and the Infectious Diseases Society of America incorporated the concept of pneumonia associated with health care (HCAP)[1], in an attempt to group a population from the community, but in frequent contact with the health system and, therefore, with an increased risk of infection by resistant pathogens (DRPs). It is known that HCAP can represent 17-22% of pneumonia seen in the hospital[1,2] and, in addition, affects older patients with more comorbidities and a higher risk of bronchoaspiration than community-acquired pneumonia (CAP)[2]. Likewise, it has a higher mortality rate, longer hospital stays and higher healthcare expenses[3].

Despite its widespread use, controversy persists in the literature around the concept of HCAP. There is a fundamental concern about the greater antibiotic pressure that the empirical treatment that its acceptance entails[4] may imply. It is argued that the concept of HCAP was established based on retrospective data from the US[3] that grouped a very heterogeneous population, without taking into account the severity, the individual risk factors for resistant pathogens, and the local epidemiology[4]. For this reason, different authors are in favour of reconsidering the HCAP term and assessing the individual risk of pneumonia due to DRPs from the individual risk of aspiration, the use of previous antibiotics and the functional state of the patient[2,4]. Other authors postulate that not all the HCAP defining criteria have the same weight in the prediction of DRPs, so they propose to use other criteria that quantify the specific weight of different risk factors, as do the Shorr index5 and the Aliberti index[6].

The main objective of our study was to evaluate the usefulness of the definition of HCAP and the Shorr and Aliberti indexes to predict the risk of DRPs pneumonia in our centre, since the definition of HCAP, despite being useful, covers an excessively heterogeneous population, so the assessment of other clinical criteria could help to select more precisely those patients who really require antibiotic coverage against DRPs.

Method

A prospective observational study was designed in which patients aged 18 years or older treated in the emergency department (ED) of the Hospital de la Santa Creu i Sant Pau in Barcelona with the diagnosis of pneumonia were included, as of December 2009 and December 2010. It is a third level university hospital that has 620 hospital beds and serves a population of approximately 425,000 people. During the study period, an average of 179 daily medical emergencies were attended, of which 0.7% were due to pneumonia.

Pneumonia was defined as the presence of a new infiltrate on the chest radiograph along with one or more compatible signs or symptoms: onset of cough or increase of it with or without expectoration, fever (temperature > 37.8°C) or hypothermia (< 35.6ºC), chills, malaise, alteration in the white series of the haemogram (leukocytosis/leukopenia) and high concentration of C-reactive protein. Exclusion criteria were: patients from other acute hospitals, with infection by the human immunodeficiency virus (HIV), terminal illness, neutropenic (neutrophil count < 1,000/mm^3) and transplanted.

During the study period, emergency physicians notified the research team when they detected an eligible patient. The researchers revised the inclusion and exclusion criteria again. The presence of a radiological infiltrate was subsequently re-evaluated by a radiologist (95% of the cases initially included by the investigating team were confirmed)[7]. If a patient had a second episode of pneumonia, he was not included again. The recruited patients were compared with 175 cases in which during the first 6 months microbial antigens were taken in urine in the presence of radiological condensation[8].

The following variables were recorded: age, sex, hospital admission requirement or in the critical unit, housing, pathological background and presence, at the discretion of the emergency physician, of bronchoaspiration risk factors. Upon arrival in the emergency room, mental state, respiratory rate, blood pressure, oxygen saturation in the air were established on the first evaluation of the patient (if they arrived with oxygen, the patient was informed by the first aid team that the patient was informed), temperature, heart rate, determination of pH, sodium, urea, glucose, haematocrit, albumin and time of onset of symptoms.

To assess the indexes analysed, an interview was conducted with all patients or their relatives by researchers trained in the use of the scales recorded and the clinical history was reviewed. The severity of pneumonia was assessed using the Pneumonia Severity Index or Fine Index[9], comorbidity with the Charlson Index[10] and functional status using the Barthel Index[11], as well as the patient's autonomy for seven instrumental activities of daily life. It was considered that a Barthel index lower than 60 points would indicate a serious functional dependence[12]. On the other hand, to assess the risk of pneumonia due to RP, the following were analysed:

- Defining criteria of HCAP[1]. Pneumonia that occurs in patients: a) hospitalized for 2 or more days in the previous 90 days; b) residents in assisted centres (residences or sociosanitary); c) in intravenous ambulatory treatment (chemotherapy or haemodialysis) or cures of skin lesions in the last 30 days; or d) cohabitants with chronic carriers of resistant pathogens.
- Shorr[5] index. Assign 4 points to patients with hospitalization of more than two days in the previous 90 days, 3 to residents of assisted centres, 2 to those on haemodialysis and 1 to patients admitted to critical units. According to the Shorr index, patients are classified as low risk (0-2 points), intermediate risk (3-5) or high risk (≥ 6).
- Index of Aliberti[6]. Assign 5 points to patients with

chronic kidney disease, (creatinine > 1.2 mg/dL), 4 to those hospitalized for more than two days in the previous 90 days, 3 to residents of assisted centres and 0.5 points for each one of the following comorbidities: cerebrovascular disease, diabetes mellitus, chronic lung disease, patients with antibiotic therapy in the 90 days prior to admission, immunosuppressed, patients on ambulatory intravenous treatment or with cures of ulcers. Patients are classified as low (0-0.5) or high (3-12.5).

Given that during the study period in our centre there was no protocol that indicated a differentiated empirical coverage for patients with HCAP, we recorded the concept of "clinical judgment of DRPs risk" if the responsible physician prescribed empiric antibiotic therapy against DRPs.

To perform the microbiological study, we included: microbial antigens in urine for *Streptococcus pneumoniae* and *Legionella pneumophila*, virological study by nasopharyngeal smear, blood cultures according to the indications recommended by the IDSA[13], culture of the sputum if the patient expectorated and the first sample of respiratory serology of *Mycoplasma pneumoniae*. The second sample for *Mycoplasma pneumoniae, Chlamydophila pneumoniae* and *Chlamydophila psittaci* was only performed in some cases. The studies were presented in a protocolled manner but, being an observational study, they were carried out according to the criteria of the physician in charge. In some patients samples were obtained for pleural fluid culture, tracheobronchial aspirate or bronchoalveolar lavage, according to clinical indication. The results were reviewed by 2 researchers. In patients without positive results in the microbiological study, the aetiology was considered indeterminate.

The result variable was the aetiology by RP according to the literature[5]: methicillin-resistant *S. aureus* (MRSA), *P. aeruginosa, Acinetobacter baumanii (A. baumanii)* and broad-spectrum beta-lactamase-producing microorganisms. As our sample did not isolate A. baumanii or beta-lactamase-producing microorganisms of extended spectrum, our outcome variable only included the isolation of *P. aeruginosa or MRSA*.

For descriptive statistical analysis, categorical variables are expressed with absolute values and percentages and continuous variables as mean ± standard deviation. The chi-squared test or the Fisher exact test were used to compare the qualitative variables. The non-parametric Mann-Whitney U test was used for the quantitative variables. Sensitivity, specificity, negative predictive value and positive predictive value were assessed using 2 x 2 tables. The risk factors associated with DRPs isolation were assessed by multiple logistic regression by forward steps. In this analysis, the study variables and the statistically significant variables were included in the bivariate analysis. The area under the receptor-operator curve (AUC-ROC) was determined for the definition of HCAP and for our final model. The goodness of fit was explored by the Homer-Lemeshow test. Values of $p < 0.05$ were considered significant. The SPSS program v.22 was used. The study was approved by the Clinical Research Ethics Committee of the Santa Creu i Sant Pau Hospital in Barcelona.

Results

139 patients were included. Table 1 shows its main clinical characteristics and the differences between patients with CAP and HCAP. Forty-nine patients (35.3%) met the HCAP criteria: 24 hospitalized in the previous 90 days (16.5%, the majority a single admission, one patient admitted twice and another 3), 21 resided in assisted centres (15.1%), 3 received endovenous treatment (2.1%), 3 received chronic cures (2.1%), 1 lived with a chronic carrier of DRPs (1.4%) and 1 was treated with haemodialysis (1 ,4%). Five of them (3.6%) simultaneously presented two criteria. They presented a medium-high risk of DRPs according to the Shorr index 43 patients (30.9%) and 56 (40.3%) according to the Aliberti index. In 25 patients (18%) a severe functional dependence was evidenced.

The aetiologic study of pneumonia was performed in 135 patients (97.1%): urine microbial antigens in 131 (97%), virological study in 122 (90.4%), first sample of respiratory serology in 101 (74.8%). %) and sputum culture in 42 (32.1%). The causative pathogen was identified in 48 patients (35.55%); 20 (41.7%) met HCAP criteria. *S. pneumoniae* was the most frequently identified pathogen (41.7%). Table 2 describes the aetiology of CAP and HCAP. DRPs were detected in 4 patients (8.7%) with HCAP and only in 1 (1.1%) with CAP ($p = 0.046$). Table 3 compares the characteristics and bivariate analysis of patients with or without DRPs isolation.

In the multivariate analysis, it was associated with an increased risk of pneumonia due to DRPs having had an income in the previous 90 days [OR 8.92 (95% CI: 1.92-41.45), $p = 0.005$], while saturation of oxygen [OR, 0.85 (95% CI: 0.74-0.98), $p = 0.028$] behaved as a protective factor. In contrast, none of the following variables were shown to be statistically significant: NACS definition, Shorr index, Alberti index, Barthel index, or the "DRPs clinical judgment". The Hosmer-Lemeshow test showed a good fit ($p = 0.996$).

Our mixed model (admissions in the previous 90 days and oxygen saturation) identified 22 patients (16.8%) at risk of DRPs with oxygen saturation cut-off points ($SatO_2$) < 90% (sensitivity 67% and specificity 50%) in patients with some admission in the previous 90 days and with $SatO_2 \leq 75\%$ (sensitivity 100% and specificity 93.5%) in patients without previous admissions. The AUC-ROC is shown in Figure 1 and the diagnostic performance in comparison to the HCAP criteria in Table 4.

When comparing the included patients with the 175 cases in which during the first 6 months microbial antigens were taken in urine in the presence of radiological condensation, no significant differences

Table 1. Clinical characteristics of patients seen in the emergency room due to community-acquired pneumonia (CAP) and health-care–associated pneumonia (HCAP)

Clinical Features	Total (N = 139) n (%)	CAP N = 90 n (%)	HCAP N = 49 n (%)	p
Men	88 (63.3)	59 (65.6)	29 (59.2)	0.467
Over 65 years old	111 (79.9)	65 (72.2)	46 (93.9)	**0.002**
Admitted	128 (92.1)	81 (90.0)	47 (95.9)	0.328
Admitted to intensive care	15 (10.8)	7 (7.8)	8 (16.3)	0.104
Aspiration risk factors	37 (26.6)	12 (13.3)	25 (51.0)	< **0.001**
Antibiotic in the previous 90 days	36 (25.9)	20 (22.2)	16 (32.7)	0.224
COPD	47 (33.8)	30 (33.3)	17 (34.7)	1
Clinical judgement DRPs	11 (7.9)	1 (1.1)	10 (20.4)	< **0.001**
Death at 30 days	7 (5)	2 (2.2)	5 (10.2)	0.096
Age (years) [mean (SD)]	75.9 (15.3)	74.2 (14.7)	80.6 (9.9)	**0.001**
Oxygen saturation: (%) [mean (SD)]	88.7 (7.3)	89.5 (7.3)	87.5 (7.2)	0.104
Albumin (mg/dl) [mean (SD)]	33.7 (6.8)	32.3 (6.4)	29.4 (4.6)	**0.03**
Symptom onset time (days) [mean (SD)]	4 (9)	7.9 (11.3)	5.3 (10.4)	0.104
Fine Index (points) [mean (SD)]	111.6 (40)	99.1 (40.4)	133.5 (29.2)	< **0.001**
Charlson Index (points) [mean (SD)]	2.4 (1.9)	1.8 (1.8)	3.7 (1.6)	< **0.001**
Barthel Index (points) [mean (SD)]	82.0 (30.6)	93.1 (15.2)	61.5 (40.1)	< **0.001**
IADL (n) [mean (SD)]	5.1 (2.8)	6.0 (2.0)	3.4 (3.1)	< **0.001**
Shorr Index (points) [mean (SD)]	1.3 (1.8)	0.1 (0.3)	3.4 (1.5)	< **0.001**
Aliberti Index (points) [mean (SD)]	2.2 (2.8)	0.6 (1.3)	5.3 (2.0)	< **0.001**

COPD: Chronic obstructive Pulmonary Disease; DRPs: Drug Resistant pathogen; IADL: Instrumental Activities of Daily Living for which the patient is autonomous on a maximum of 7; SD: Standard Deviation; p < 0.05 are highlighted in bold.

were found in sex, or positivity of the antigens for Streptococcus pneumoniae or *Legionella pneumophila*, although the patients in the study were older [75.9 (15.3) vs. 71.6 (17.9) years, p = 0.028] and more history of chronic obstructive pulmonary disease (COPD) (33.8% vs. 20.5%, p = 0.018).

Discussion

Our study provides data of clinical utility for the empirical antibiotic coverage of pneumonia from the community and shows that in our hospital admission in the previous 3 months and the presence of low oxygen saturation better discriminate the aetiology of pneumonia RP than the HCAP concept itself, the Shorr or Aliberti indexes, the functional status or the clinical judgment of the emergency physician.

Among our patients, DRPs were isolated in 8.7% of

Table 2. Confirmed aetiology of patients seen in the emergency room due to community-acquired pneumonia (CAP) and health-care–associated pneumonia (HCAP)

	Total (N = 48) n (%)	CAP (N = 28) n (%)	HCAP (N = 20) n (%)
Streptococcus pneumoniae	20 (41.7)	12 (41.4)	8 (42.1)
Virus*	13 (27.1)	8 (28.6)	5 (25)
Legionella pneumophila	5 (10.4)	4 (14.3)	1 (5)
Haemophilus influenzae	3 (6.2)	2 (7.1)	1 (5)
Pseudomonas aeruginosa	3 (6.2)	0	3 (15)
MRSA	2 (4.12)	1 (3.6)	1 (5)
Nocardia	2 (4.2)	0	2 (10)
Mycobacterium tuberculosis	2 (4.2)	2 (7.1)	0
Mycoplasma pneumoniae	1 (2.1)	1 (3.6)	0

MRSA: Methicillin-resistant *Staphylococcus aureus*; in 2 patients mixed etiology was detected: 1 patient with Nocardia + respiratory syncytial virus and 1 patient with influenza A + H. influenzae virus.
* In CAP: 2 influenza A viruses, 2 rhinoviruses, and 4 respiratory syncytial viruses; in HCAP: 1 rhinovirus, 2 adenoviruses, 1 metapneumovirus and 1 respiratory syncytial virus.

Table 3. Clinical characteristics of patients with positive aetiology for resistant pathogens (MRSA and *P. aeruginosa*) and the rest of patients

	Resistant Pathogens N = 5 n (%)	Non-resistant pathogens N = 130 n (%)	p
Men	4 (80.0)	83 (63.8)	0.655
Admitted	5 (100.0)	119 (91.5)	1
Admitted to Intensive Care	2 (40.0)	13 (10.0)	0.095
NACS	4 (80.0)	42 (32.3)	**0.046**
Clinical Judgement*	2 (40.0)	8 (6.2)	**0.044**
COPD	4 (80.0)	42 (32.3)	**0.046**
Bronchoaspiration risk factor	2 (40.0)	33 (25.4)	0.604
Antibiotic in the precious 90 days	31 (23.8)	3 (2.3)	0.101
Previous Admissions	3 (60.0)	18 (13.8)	**0.027**
Assisted Centres	0	19 (14.6)	1
Haemodialysis	0	1 (0.8)	1
Death at 30 days	1 (20)	6 (4.6)	0.346
Age [mean (SD)]	78.0 (10.2)	75.6 (15.6)	0.907
Oxygen Saturation [mean (SD)]	83.0 (8.8)	89.2 (6.8)	0.079
Albumin [mean (SD)]	28.4 (3.0)	31.7 (6.2)	0.106
Symptoms Onset time [mean (SD)]	3.0 (2.0)	7.5 (11.1)	0.381
Fine Index [mean (SD)]	128.0 (27.8)	109.9 (40.1)	0.221
Charlson Index [mean (SD)]	3.6 (1.5)	2.3 (1.9)	0.124
Barthel Index [mean (SD)]	90.0 (12.2)	83.6 (29.3)	0.645
IADL [mean (SD)]	5.8 (2.2)	5.2 (2.7)	0.790
Shorr Index [mean (SD)]	2.8 (1.6)	1.1 (1.8)	**0.006**
Aliberti Index [mean (SD)]	4.4 (3.6)	2.1 (2.7)	0.158

HCAP: Health care-associated pneumonia; COPD: Chronic obstructive pulmonary disease; Previous admissions: one or more previous admissions in the last 90 days; IADL: Instrumental activities of daily living. SD: Standard deviation. The p < 0.05 are highlighted in bold. *Clinical judgment of risk of resistant pathogens.

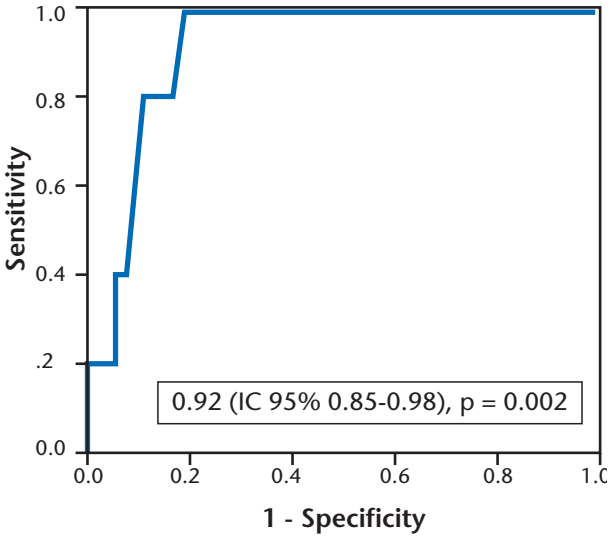

Figure 1. Area under the curve-ROC of the model that includes oxygen saturation and the previous number of admissions. The diagonal segments are produced by ties.

the HCAP and 1.1% of the CAP. These data are in line with other European studies that find prevalences of RP of 5% in HCAP and 2% in CAP, although there is considerable heterogeneity depending on the study period or the type of patients evaluated (admitted, attended in the emergency department) or only patients with a confirmed microbiological diagnosis)[14]. As described repeatedly in different publications[14-17], the concept of HCAP was associated with the aetiology of DRPs also in our patients with a good negative predictive value, but its systematic use as the only criterion for the indication of empirical antibiotic of very broad spectrum. It would have entailed an excessive use of antibiotics in a third of the patients attended, with the consequent sanitary cost, risk of side effects and the appearance of resistance. Our model maintains the negative predictive value and improves the positive predictive value, since it reduces to 12.7% the patients that initially would require broad-spectrum empirical coverage without subsequent confirmation of DRPs. Other proposed approaches to assess DRPs risk such as Shorr[5] Index, Aliberti Index[6] or functional status[4] did not show predictive value in our study. Both these models and others described later, present a wide variety of predictive variables and tend to favour excessive antibiotic treatment[17,18]. Unfortunately, our study shows that the clinical judgment of the physician treating the patient with pneumonia is not sufficiently precise to identify patients who require empirical coverage against DRPs.

In our study, admission to the hospital in the previous 3 months was not only the criterion that most frequently defined patients as HCAP, but it was also the only one that showed significance in the multivariate analysis, given that each admission multiplies the risk of DRPs by 8. This is a criterion that appears repeatedly in practically all the series studied and that is present in most predictive models of DRPs[16]. However, the criterion of residing in assisted centres, although numerically it is almost as frequent as that of previous admissions, was not associated with the presence of DRPs. The majority of studies that incorporate this criterion as a DRPs risk factor are from the United States. Probably the difference is justified by the lower complexity of care and antibiotic pressure in Spanish homes compared to the "nursing home" in the United States, more similar to our sociosanitary centres. It is therefore essential to know those factors of greater importance and the epidemiology of our care environment, especially from data collected prospectively[19].

Especially relevant is the predictive value of DRPs of $SatO_2$ in the air in the first assessment of the patient. Assessing the oxygen concentration in patients with pneumonia is crucial for correct treatment and influences the prognosis beyond the estimates provided by the severity indexes[9]. In fact, it is considered one of the criteria of quality in the attention to pneumonias, and nowadays, it is carried out in practically all patients attended thanks to the accessibility of pulse oximetry[20], which has been shown to be sufficiently precise for a correct initial valuation[21]. In spite of this, it is a variable little analysed in the studies on DRPs risk, probably because it needs to register adequately prospectively. However, some previous studies have shown the predictive value of PO_2/FiO_2 for DRPs[22] pneumonia and, in particular, for *Pseudomonas aeruginosa*[23]. Even the saturation value ≤ 90% has been shown to be a predictor of pathogenicity due to MRSA in the HCAP[24]. These results have been related to the greater virulence of the DRPs, which present with more severe pneumonias and without response to the initial outpatient treatment[24,25]. Possibly, desaturation also identifies patients who present more easily with hypoxemia in the presence of pneumonia, such as those with COPD, comorbidity that is associated both in our study and in those prior to DRPs[23,26]. The $SatO_2$ is therefore an objective value, of habitual use and of great clinical utility to be a predictor of RP and, in addition, to indicate severity. One of the current trends is to include severity in the decision on antibiotic coverage[18]. $SatO_2$ is an especially useful variable because in false negatives probably the best oxygenation status allows to wait for 24-48 hours of microbiological results (our only false negative had a good evolution after starting the appropriate antibiotic differentially).

Among the limitations of our study is the fact that it

Table 4. Diagnostic performance of our model against the criteria of health care-associated pneumonia (HCAP)

	Sensitivity	Specificity	Positive Predictive value	Negative predictive value	False Positives	False Negatives
Our Model (%)	80	87.3	20	99.1	12.7	0.9
HCAP (%)	80	67.7	8.7	98.9	32.3	0.9

is a study carried out in a single centre, without a confirmed aetiology in all patients and with a low percentage of DRPs. Despite being an observational study, a microbiological study was conducted in a large number of patients and microbiological identification was obtained in 35.5%, a finding consistent with previous studies. However, microbiological diagnosis has not been achieved in the majority of patients, which could introduce a selection bias. It should also be borne in mind that obtaining adequate samples is more difficult in elderly patients with functional impairment who precisely meet the defining criteria of HCAP more frequently. Although the lack of an etiological diagnosis in all cases generates some uncertainty regarding the results, it is a common problem in pneumonia studies based on clinical practice[25]. In addition, the recruitment of patients with pneumonia prospectively is complicated by precise clinical and radiological diagnosis. In the context of the high demand for emergency care, no data were collected from excluded patients. Both the structure of our ED and the greater age and comorbidity of the sample studied, we believe that some patients were lost, especially those younger than those who received outpatient treatment. The detailed description of the sample and its recruitment tells us in which patients our results may be applicable. As a main strength, the identification of the patients was prospectively performed in the ED, which allowed us to record variables of great clinical utility such as the initial measurement of $SatO_2$ in the air and the inclusion of both inpatients and outpatients. In addition, our study not only analyses previously proposed models, but also the clinical judgment of the physicians who treated patients in the emergency department, a variable that is not usually analysed in similar studies.

In conclusion, the concept of HCAP maintains its negative predictive value in our environment, but its capacity for discrimination is not sufficient to guide the start of broad-spectrum antibiotic coverage, since we would incur antibiotic abuse. In patients with HCAP, the emergency doctor should increase the clinical suspicion, study aetiology whenever possible and individualize the antibiotic coverage, for which he should especially consider the previous income and the $SatO_2$ to help in decision making.

Conflicting interests

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Ethical Responsibilities

The study was approved by the Clinical Research Ethics Committee of the Santa Creu i Sant Pau Hospital in Barcelona.

Informed consent was obtained from participants.

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References

1 American Thoracic, Society H. Guidelines for the Management of Adults with Hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. Am J Respir Crit Care Med. 2005;171:388-416.
2 Carratalà J, Mykietiuk A, Fernández-Sabé N, Suárez C, Dorca J, Verdaguer R, et al. Health care-associated pneumonia requiring hospital admission: epidemiology, antibiotic therapy, and clinical outcomes. Arch Intern Med. 2007;167:1393-9.
3 Kollef MH, Shorr A, Tabak YP, Gupta V, Liu LZ, Johannes RS. Epidemiology and outcomes of health-care-associated pneumonia: Results from a large US database of culture-positive pneumonia. Chest. 2005;128:3854-62.
4 Ewig S, Welte T, Chastre J, Torres A. Rethinking the concepts of community-acquired and health-care-associated pneumonia. Lancet Infect Dis. 2010;10:279-87.
5 Shorr AF, Zilberberg MD, Micek ST, Kollef MH. Prediction of infection due to antibiotic-resistant bacteria by select risk factors for health care-associated pneumonia. Arch Intern Med. 2008;168:2205-10.
6 Aliberti S, Di Pasquale M, Zanaboni AM, Cosentini R, Brambilla AM, Seghezzi S, et al. Stratifying risk factors for multidrug-resistant pathogens in hospitalized patients coming from the community with pneumonia. Clin Infect Dis. 2012;54:470-8.
7 Torres O, Gil E, Giménez A, Franquet T, Alfonso S, Pacho C, et al. A-204 Radiological characteristics of severe pneumonia and comparison of evaluations by emergency physicians and radiologists. Rev Clin Esp. 2012;212(Espec Congr):S162.
8 Torres O, Pérez E, Cáceres C, Gil E, Pacho C, Mateo M, et al. Empleo de los antígenos microbianos en orina en los pacientes con EPOC. Rev Clin Esp. 2011;211(Supl C):S87.
9 Fine MJ, Auble TE, Yealy DM, Hanusa BH, Weissfeld LA, Singer DE, et al. A prediction rule to identify low-risk patients with community-acquired pneumonia. N Engl J Med. 1997;336:243-50.
10 Charlson ME, Pompei P, Ales KL, Mackenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. J Chron Dis. 1987;40:373-83.
11 Mahoney FI, Barthel DW. Functional evaluation: The Barthel index. Md State Med J. 1965;14:61-5.
12 Shah S, Vanclay F, Cooper B. Improving the sensitivity of the Barthel Index for stroke rehabilitation. J Clin Epidemiol. 1989;42:703-9.
13 Mandell LA, Wunderink RG, Anzueto A, Bartlett JG, Campbell GD, Dean NC, et al. Infectious Diseases Society of America/American Thoracic Society Consensus Guidelines on the Management of Community-Acquired Pneumonia in Adults. Clin Infect Dis. 2007;44:S27-72.
14 Cardoso T, Almeida M, Carratalà J, Aragão I, Costa-Pereira A, Sarmento AE, et al. Microbiology of healthcare-associated infections and the definition accuracy to predict infection by potentially drug resistant pathogens: a systematic review. BMC Infect Dis. 2015;15:565.
15 Chalmers JD, Rother C, Salih W, Ewig S. Healthcare-associated pneumonia does not accurately identify potentially resistant pathogens: A systematic review and meta-analysis. Clin Infect Dis. 2014;58:330-9.
16 Webb BJ, Dascomb K, Stenehjem E, Dean N. Predicting risk of drug-resistant organisms in pneumonia: Moving beyond the HCAP model. Respiratory Medicine. 2015;109:1-10.
17 Self WH, Wunderink RG, Williams DJ, Barrett TW, Baughman AH, Grijalva CG. Comparison of Clinical Prediction Models for Resistant Bacteria in Community-onset Pneumonia. Acad Emerg Med. 2015;22:730-40.
18 Webb BJ, Jones B, Dean NC. Empiric antibiotic selection and risk prediction of drug-resistant pathogens in community-onset pneumonia. Curr Opin Infect Dis. 2016;29:167-77.
19 Waterer GW. Healthcare-associated pneumonia: Can we salvage anything from the wreckage? Respirology. 2016;21:8-9.
20 Metersky ML. Should management of pneumonia be an indicator of quality of care? Clinics in Chest Medicine. 2011;32:575-89.
21 Sanz F, Dean N, Dickerson J, Jones B, Knox D, Fernández-Fabrellas E, et al. Accuracy of PaO_2/FiO_2 calculated from SpO_2 for severity assessment in ED patients with pneumonia. Respirology. 2015;20:813-8.
22 Falcone M, Russo A, Giannella M, Cangemi R, Scarpellini MG, Ber-

tazzoni G, et al. Individualizing risk of multidrug-resistant pathogens in community-onset pneumonia. PLoS One. 2015;10:e0119528.
23 Prina E, Ranzani OT, Polverino E, Cillóniz C, Ferrer M, Fernandez L, et al. Risk factors associated with potentially antibiotic-resistant pathogens in community-acquired pneumonia. Ann Am Thorac Soc. 2015;12:153-60.
24 Enomoto Y, Yokomura K, Hasegawa H, Ozawa Y, Matsui T, Suda T. Healthcare-associated pneumonia with positive respiratory methicillin-resistant Staphylococcus aureus culture: Predictors of the true pathogenicity. Geriatr Gerontol Int. 2017;17:456-62.
25 Falcone M, Russo A, Giannella M, Cangemi R, Scarpellini MG, Bertazzoni G, et al. Individualizing risk of multidrug-resistant pathogens in community-onset pneumonia. PLoS One. 2015;10:e0119528.
26 Liapikou A, Polverino E, Ewig S, Cillóniz C, Marcos MA, Mensa J, et al. Severity and outcomes of hospitalised community-acquired pneumonia in COPD patients. Eur Respir J. 2012;39:855-61.