Predictors of Hospital Admission Two Months after Emergency Department Evaluation of COPD Exacerbation

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Key Words

COPD exacerbations · Short-term hospital admissions · Emergency department evaluation · Predictive factors · Prospective cohort study

Abstract

Background: Limited information is available regarding the factors related to short-term hospital admission following an exacerbation of chronic obstructive pulmonary disease (eCOPD). **Objectives:** The aim of this study was to identify variables related to short-term admission in patients with an eCOPD. **Methods:** This was a prospective cohort study of patients with an eCOPD who attended an emergency department (ED) at 1 of 16 hospitals. Information on possible predictor variables was recorded during the ED stay, 24 h after admission to the hospital or after ED discharge home, and at hospital discharge or 1 week later if discharged home from the ED. An admission after an eCOPD within 2 months was the outcome of interest. Multivariate models were employed for patients admitted to the hospital or discharged home from the ED. **Results:** For patients discharged home from the ED, eCOPD-related hospital admissions in the previous year [odds ratio (OR) 1.98 and 2.33], pCO₂ at ED admission (ORs

2.02 and 2.90), the number of ED visits within 1 week of the index ED visit (OR 5.14) and dyspnea level 1 week after the index ED visit (ORs 2.66 and 1.40) were predictors of short-term admission [area under the curve (AUC) 0.82]. For patients admitted to the hospital during the index ED visit, baseline FEV₁% (ORs 1.32 and 1.88), eCOPD-related hospital admissions in the previous year (ORs 1.28 and 2.51), severe baseline dyspnea (OR 2.57) and dyspnea level 1 week after the index ED visit (ORs 2.15 and 1.74) were predictors of short-term readmission (AUC 0.73). **Conclusions:** Just a few easily recorded parameters may allow clinicians to identify patients at a higher risk of short-term readmission and establish preventive strategies.

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Introduction

In developed countries, chronic obstructive pulmonary disease (COPD) is a leading cause of morbidity and mortality. Much of its impact is related to exacerbations – sudden worsening of symptoms that may last for several days – which are part of the evolution of the disease in some patients [1, 2]. Exacerbations are also related

to subsequent hospital admission and readmission [3–5]. Exacerbations account for more than 70% of COPD costs due to emergency visits and hospitalizations [6]. Thus, identifying parameters that predict hospital admission in eCOPD patients may help establish interventions or controls that improve patients' quality of life and prognosis while reducing the rate of admission [7].

Several studies have attempted to identify parameters related to readmission in eCOPD patients [8, 9], but most of them have concentrated on long periods immediately after emergency department (ED) evaluation of patients experiencing an eCOPD or upon their discharge from the hospital [10–12]. As far as we know, they have also only concentrated on the follow-up of patients admitted to the hospital, thus excluding patients with exacerbations who are not admitted to the hospital or only receiving primary care.

The goal of this study was to identify, in a large cohort of eCOPD patients, the risk factors related to short-term admission for the patients admitted to the hospital after the index ED visit or for those discharged home.

Methods

This prospective cohort study included 16 hospitals registered with the Spanish National Health Service (SNS). The majority of the Spanish population (99.8%) is covered by the SNS. All centers present similar technological and human resources. So far, all individuals covered by the SNS have free access to a primary care physician and to the ED of the hospitals. Patients with an eCOPD attending the ED of any of these hospitals between June 2008 and September 2010 were informed of the goals of the study and invited to voluntarily participate. In order to take part in the study, a patient had to provide informed consent. All information was kept confidential. The institutional review boards of the participating hospitals approved this project. A more detailed description of the study protocol has been published previously [13].

Patients were eligible for the study if they presented to the ED of 1 of the hospitals with symptoms consistent with an eCOPD. COPD was confirmed if the patient had a FEV₁/FVC ratio of <70%. An eCOPD was defined as an event in the natural course of the disease characterized by a change in the patient's baseline dyspnea, cough and/or sputum beyond the normal day-to-day variations, and that may have warranted a change in regular medication in a patient with underlying COPD [14]. Patients newly diagnosed with COPD in the ED had to have this confirmed by spirometry within 60 days after the index episode at a time when they were stable, in order for them to be included in the study [15]. Patients in the ED were excluded from the study if they experienced an eCOPD complicated by a comorbidity such as pneumonia, pneumothorax, pulmonary embolism, lung cancer or left cardiac insufficiency. Other exclusion criteria included a diagnosis of asthma, extensive bronchiectasis, tuberculosis sequelae, pleural thickening or restrictive diseases. Patients who did not wish to participate were also excluded.

Data Collected

The data collected upon arrival in the ED included socioeconomic details, the patient's respiratory status (arterial blood gases including pH, pCO₂ and pO₂, respiratory rate and dyspnea at rest), consciousness level (measured by the Glasgow Coma Scale [16]) and the presence of other disease conditions recorded in the Charlson Comorbidity Index [17]. Data collected in the ED at the time a decision was made to admit the patient or discharge him or her home included the symptoms, signs and respiratory status at that moment.

For the patients who were admitted to the hospital, we collected additional data directly from the medical records and from an interview with the patient on the first day after admission and on the day of discharge. Data related to the patient's respiratory status was also recorded at discharge, if available. For patients discharged home from the ED, telephone interviews were conducted approximately 24 h and 1 week after discharge to assess their evolution and vital status. Twenty-four hours after the index ED visit, all patients were asked about their general health status prior to the exacerbation and their levels of dyspnea and physical activity (PA) when stable. Overall health was assessed by means of the question: 'In general, how would you characterize your health?' The 6 possible answers ranged from 'very bad' to 'excellent'. To measure the level of dyspnea at baseline, we used the (MRC) Medical Research Council breathlessness scale [18]. The dyspnea level 24 h and 1 week after the index ED visit or at hospital discharge was measured with a specific request 'Rate your level of dyspnea today' using a 7-category scale ranging from 'very severe' to 'none', similar to the Borg dyspnea scale [19]. Levels of PA were assessed using a 7-category scale from 'doesn't leave the house, life is limited to the bed or armchair' to 'practises sports' [20]. The same assessments of general health, dyspnea and PA were made at the time of discharge for patients admitted to the hospital at the index ED visit or 1 week after the index ED visit for patients discharged home.

Additional variables collected from medical records included the baseline severity of COPD, as measured by FEV₁% obtained from spirometry, smoking status, hospital admissions due to eCOPD during the previous 12 months, baseline COPD therapy (inhaled short-/long-acting beta agonists, short-/long-acting anticholinergics, oral or inhaled corticosteroids, theophyllines, antibiotics, diuretics and/or the need of noninvasive mechanical ventilation or long-term home oxygen therapy), therapy received during the ED stay and at ED discharge or during the hospital stay or at discharge including corticotherapy, ICU or intermediate respiratory care unit admissions. Reviewers were trained and a precise manual was developed to be followed in the collection of data from the medical records (electronic or paper).

Definition of Outcome Measures

The primary outcome was hospital admission or readmission within 2 months of the index ED evaluation for an eCOPD.

Statistical Analyses

The unit of the analysis was the patient. For patients who had more than 1 ED visit during the recruitment period, the first visit was considered for the analysis. Patients who died between the index ED visit and the end of the 2-month follow-up were removed from the analysis. As expected, patients who died presented statistically significant differences in several variables (e.g. age, FEV₁, previous admissions, comorbidities, signs, symptoms and labora-

Fig. 1. Flowchart of the recruitment and follow-up process.

tory test results upon ED admission) compared to the patients included in our analysis.

To identify variables related to hospital admission 2 months after ED evaluation of an eCOPD, we performed separate univariate analyses according to a patient's status at the ED, i.e. whether they were admitted to the hospital or discharged home. All previously mentioned variables (sociodemographic, comorbidities, severity of COPD, treatments, clinical status upon arrival at the ED, discharge from the ED or hospital, basic biochemistry, ECG and X-ray findings in the ED, complications during hospital admission, the self-reported general health of patients, PA and dyspnea) were analyzed. The χ^2 and Fisher exact tests were used to test for statistical significance among proportions, and the Student *t* test or Wilcoxon *U* test was used for continuous variables. Variables with statistically significant results at $p < 0.20$ were entered into multivariate models. Since some of the possible predictive variables (e.g. dyspnea and general health) were recorded at different time points for the same patient, generalized linear mixed models were used, with hospital admission within 2 months of the index ED visit as the outcome of interest [21]. In addition, hospitals were considered as random effects in the multivariate models. To assess the discriminative power of the model, the area under the curve (AUC) for repeated measures was computed [22].

All results were displayed as odds ratios (ORs) with their 95% confidence intervals (95% CIs). All effects were considered sig-

nificant at $p < 0.05$ unless otherwise stated. All statistical analyses were performed using SAS for Windows statistical software, version 9.2 (SAS Institute, Inc., Cary, N.C., USA).

Results

A total of 3,276 episodes were recruited for the study, but after applying the selection criteria, 2,336 patients made up the final study sample, 430 patients (18.40%) having admitted to a hospital for an eCOPD within 2 months of the index ED visit (fig. 1). The characteristics of all patients, those admitted to the hospital and those discharged home from the ED are presented in table 1.

Univariate analysis variables related to hospital admission for a new eCOPD within 2 months of the index ED visit are shown in table 2 for patients discharged home from the index ED visit and in table 3 for those admitted to the hospital at this visit. Baseline FEV₁, previous admissions or use of long-term home oxygen therapy and dyspnea levels at different points in time were the main com-

Table 1. Patient characteristics by admission or discharge status at the index ED visit

	Total (n = 2,332)	Hospital admission at index ED visit		p value
		yes (n = 1,403)	no (n = 929)	
Mean age $\pm$ SD, years	72.51 $\pm$ 9.64	72.32 (9.63)	72.80 (9.65)	0.23
Sex				0.45
Male	2,125 (91.12)	1,273 (90.73)	852 (91.71)	
Female	207 (8.88)	130 (9.27)	77 (8.29)	
FEV ₁ %				<0.0001
≥ 50	737 (35.88)	404 (31.46)	333 (43.25)	
30–49	940 (45.76)	604 (47.04)	336 (43.64)	
<30	377 (18.35)	276 (21.50)	101 (13.12)	
Baseline dyspnea (MRC scale ^a)				0.36
1	188 (8.91)	104 (8.02)	84 (10.33)	
2	588 (27.87)	363 (27.99)	225 (27.68)	
3	474 (22.46)	287 (22.13)	187 (23)	
4	635 (30.9)	399 (30.76)	236 (29.03)	
5	225 (10.66)	144 (11.10)	81 (9.96)	
Smoking status				<0.0001
Current smoker	307 (18.75)	201 (19.98)	97 (16.55)	
Ex-smoker	1,260 (76.97)	814 (77.45)	446 (76.11)	
Never-smoker	70 (4.28)	27 (2.57)	43 (7.34)	
Charlson Comorbidity Index				0.03
≤ 2	1,615 (69.25)	948 (67.57)	667 (71.80)	
>2	717 (30.75)	455 (32.43)	262 (28.20)	
Chronic heart failure				0.76
Yes	1,789 (77.05)	1,070 (76.81)	719 (77.40)	
No	533 (22.95)	323 (23.19)	210 (22.60)	
Previous LTHOT or NIMV				<0.0001
No	1,584 (67.92)	905 (64.50)	679 (73.09)	
Yes	748 (32.08)	498 (35.50)	250 (26.91)	
Admission for eCOPD in the last year				<0.0001
0	1,365 (59.40)	611 (67.07)	754 (54.36)	
1	493 (21.45)	184 (20.20)	309 (22.28)	
≥ 2	440 (19.15)	116 (12.73)	324 (23.36)	
Edema (at ED arrival)	397 (18.15)	264 (20.29)	133 (15.01)	<0.0001
pH (at ED arrival)				<0.001
>7.35	1,884 (87.51)	1,088 (82.24)	796 (95.90)	
7.26–7.35	226 (10.50)	192 (14.51)	34 (4.10)	
<7.26	43 (2.00)	43 (3.25)	0 (0)	
pCO ₂ , mm Hg (at ED arrival)				<0.001
<45	1,178 (58.40)	670 (52.06)	508 (69.59)	
45–55	448 (22.21)	288 (22.38)	160 (21.92)	
>55	391 (19.39)	329 (25.56)	62 (8.49)	
Dyspnea at rest (at ED arrival)				≤ 0.0001
No	740 (33.36)	289 (21.73)	451 (50.79)	
Yes	1,478 (66.64)	1,041 (78.27)	437 (49.21)	
Altered mental status (at ED arrival)	52 (2.23)	42 (3.00)	10 (1.08)	0.002
Dyspnea 24 h after the index ED visit ^b				<0.001
Very severe/severe	993 (46.42)	699 (53.24)	294 (35.59)	
Moderate	481 (22.49)	251 (19.12)	230 (27.85)	
None/very slightly	665 (31.09)	363 (27.65)	302 (36.56)	
Dyspnea at 1 week/discharge after ED visit ^b				<0.0001
Very severe/severe	471 (22.69)	260 (20.50)	211 (26.11)	
Moderate	515 (24.81)	301 (23.74)	214 (26.49)	
None/very slightly	1,090 (52.50)	707 (55.76)	383 (47.40)	

Table 1 (continued)

	Total (n = 2,332)	Hospital admission at index ED visit		p value
		yes (n = 1,403)	no (n = 929)	
General health 24 h after the index ED visit				<0.001
Poor–very poor	660 (30.86)	494 (37.62)	166 (20.10)	
Good–fair	1,424 (66.57)	801 (61.01)	623 (75.42)	
Excellent–very good	55 (2.57)	18 (1.37)	37 (4.48)	
Median length of stay (P ₂₅ –P ₇₅), days	6 (4–9)	6 (4–9)	–	
eCOPD-related admission within 2 months of index ED visit				<0.0001
No	1,902 (81.56)	1,104 (78.69)	798 (85.90)	
Yes	430 (18.44)	299 (21.31)	131 (14.10)	

Values are presented as n (%) unless otherwise indicated. LTHOT = Long-term home oxygen therapy; NIMV = noninvasive mechanical ventilation. ^a A scale of respiratory disability, grades 1–5, i.e. from no incapacity to almost complete incapacity. ^b Measured on a 7-category scale.

Table 2. Univariate analysis of predictors of eCOPD-related admission within 2 months among patients discharged home at the index ED visit

	Readmission	
	OR (95% CI)	p value
Baseline FEV ₁ %		
>30 and <50 vs. ≥50	1.89 (1.18–3.03)	0.008
<30 vs. ≥50	2.95 (1.63–5.36)	0.004
pCO ₂ , mm Hg (at ED arrival)		
45–55 vs. <45	2.23 (1.35–3.68)	0.002
>55 vs. <45	3.08 (1.59–5.98)	0.001
Chronic heart failure		
Yes vs. no	1.37 (0.85–2.22)	0.20
Admissions for eCOPD in the last year		
1 vs. 0	2.45 (1.55–3.87)	0.0001
≥2 vs. 0	4.02 (2.47–6.55)	<0.001
Previous LTHOT or NIMV at home		
Yes vs. no	1.92 (1.30–2.85)	0.001
Baseline dyspnea (MRC scale ^a)		
2 vs. 1	0.79 (0.36–1.76)	0.56
3 vs. 1	1.13 (0.51–2.51)	0.76
4 vs. 1	1.80 (0.86–3.78)	0.12
5 vs. 1	1.86 (0.79–4.40)	0.16
Dyspnea levels 24 h after the index ED visit ^b		
Very severe/severe vs. none/very slight	2.52 (1.54–4.12)	0.0002
Moderate vs. none/very slight	1.46 (0.84–2.53)	0.18
Dyspnea levels 1 week after the index ED visit ^b		
Very severe/severe vs. none/very slight	4.35 (2.70–7.00)	<0.001
Moderate vs. none/very slight	1.41 (0.80–2.48)	0.23
Visits to the ED within 1 week of the index ED visit		
Yes vs. no	3.76 (2.21–6.40)	<0.001

General health was measured via the question ‘Would you say your health today is excellent, very good, good, fair, poor or very poor?’ LTHOT = Long-term home oxygen therapy; NIMV = noninvasive mechanical ventilation. ^a A scale of respiratory disability, grades 1–5, i.e. from no incapacity to almost complete incapacity. ^b Measured on a 7-category scale.

Table 3. Univariate analysis of predictors of eCOPD-related admissions within 2 months among patients admitted to the hospital at the index ED visit

	Readmission	
	OR (95% CI)	p value
Baseline FEV ₁ %		
>30 and <50 vs. ≥50	1.96 (1.37–2.81)	0.0002
<30 vs. ≥50	3.08 (2.05–4.63)	<0.001
Chronic heart failure		
Yes vs. no	1.46 (1.09–1.95)	0.01
Admissions for eCOPD in the last year		
1 vs. 0	1.77 (1.26–2.48)	0.001
≥2 vs. 0	3.28 (2.39–4.49)	<0.001
Previous LTHOT/NIMV at home		
Yes vs. no	1.59 (1.22–2.06)	0.001
Baseline dyspnea (MRC scale ^a)		
2 vs. 1	1.46 (0.72–2.94)	0.29
3 vs. 1	2.52 (1.25–5.12)	0.01
4 vs. 1	2.50 (1.26–4.97)	0.01
5 vs. 1	5.20 (2.48–10.90)	<0.001
Dyspnea 24 h after the index ED visit ^b		
Very severe/severe vs. none/very slight	1.40 (0.99–1.99)	0.06
Moderate vs. none/very slight	1.17 (0.76–1.79)	0.48
Dyspnea 1 week after the index ED visit ^b		
Very severe/severe vs. none/very slight	2.53 (1.79–3.57)	<0.001
Moderate vs. none/very slight	1.72 (1.21–2.45)	0.002

General health was measured via the question ‘Would you say your health today is excellent, very good, good, fair, poor or very poor?’ LTHOT = Long-term home oxygen therapy; NIMV = noninvasive mechanical ventilation. ^a A scale of respiratory disability, grades 1–5, i.e. from no incapacity to almost complete incapacity. ^b Measured on a 7-category scale.

mon variables in both these groups of patients. No differences were observed in previous treatments for the current eCOPD or in the rate of patients previously attended by their primary care physician among patients admitted to hospital or discharged after the index ED visit. In addition, none of the treatments prescribed to patients discharged home from the ED or applied to patients admitted to the hospital had any relationship with future exacerbations.

We performed separate multivariate analyses for patients admitted to hospital and discharged home at the index ED visit. Variables related to admission for an eCOPD within 2 months of the index ED visit among patients discharged home from the ED are shown in table 4. Worse pCO₂ upon arrival at ED, eCOPD-related hospital admissions in the year before the index ED visit, a worse level of dyspnea 1 week after the index ED visit and new visits to the ED in the week following the index ED visit were all related to hospital admission for an eCOPD within 2 months (AUC 0.82). After removing pCO₂, heart failure as a comorbidity was significant (OR 1.79 and 95% CI

1.01–3.20). Model 2 shows the variables related to admission for a new eCOPD within 2 months of the index ED visit among the patients admitted to the hospital at the index ED visit. Worse baseline COPD status (measured by baseline FEV₁%), previous eCOPD-related hospital admissions in the year before the index ED visit, worse baseline level of dyspnea (measured on the MRC scale) and worse level of dyspnea 1 week after the index ED visit correlated with eCOPD-related hospital readmission within 2 months (AUC 0.73). All models were adjusted according to the level of dyspnea 24 h after arrival at the ED and participant hospital.

Discussion

This prospective cohort study, which included a large sample of patients visiting different EDs for evaluation of an eCOPD, identified several variables related to hospital admission within 2 months of the index ED visit. Variables

Table 4. Multivariate analysis of predictors of eCOPD-related admissions within 2 months of the index ED visit

	Readmission	
	OR (95% CI)	p value
<i>MODEL 1: Patients discharged home</i>		
Admissions for eCOPD in the last year		
1 vs. 0	1.98 (1.07–3.70)	0.03
≥2 vs. 0	2.33 (1.19–4.56)	0.01
pCO ₂ mm Hg (at ED arrival)		
45–55 vs. <45	2.02 (1.11–3.67)	0.02
>55 vs. <45	2.90 (1.29–6.54)	0.01
Dyspnea 1 week after the index ED visit		
Very severe/severe vs. none/very slight	2.66 (1.36–5.20)	0.005
Moderate vs. none/very slight	1.40 (0.67–2.91)	0.37
Visits to the ED within 1 week of the index ED visit		
Yes vs. no	5.14 (2.47–10.70)	<0.0001
<i>MODEL 2: Patients admitted to the hospital</i>		
Baseline FEV ₁ %		
>30 and <50 vs. ≥50	1.32 (0.89–1.95)	0.17
<30 vs. ≥50	1.88 (1.19–2.95)	0.006
Admissions for eCOPD in the last year (mean)		
1 vs. 0	1.28 (0.86–1.92)	0.23
≥2 vs. 0	2.51 (1.74–3.62)	<0.001
Baseline dyspnea (MRC scale)		
2–3–4 vs. 1	1.49 (0.71–3.14)	0.29
5 vs. 1	2.57 (1.10–6.01)	0.03
Dyspnea 1 week after the index ED visit		
Very severe/severe vs. none/very slight	2.15 (1.44–3.23)	<0.001
Moderate vs. none/very slight	1.74 (0.71–3.14)	0.005

AUC for patients discharged home: 0.82. AUC for patients admitted to the hospital: 0.73. Multivariate analysis was performed with generalized linear mixed models for repeated measures adjusted (according to dyspnea 24 h after the index ED visit in both models).

common to patients discharged home and those admitted to the hospital at the index ED visit include changes in levels of dyspnea from 24 h after the initial assessment at the ED up to 1 week, and the number of eCOPD-related admissions in the previous year. For those discharged home from the ED, additional variables associated with a higher risk of short-term admission were pCO₂ levels upon arrival at the ED and additional visits to the ED within 7 days of the index ED visit. For those admitted to the hospital during the index ED visit, a worse dyspnea level in a stable clinical situation and baseline FEV₁ play key roles in the prediction of short-term hospitalization for a new eCOPD.

In both groups, we observed that the number of eCOPD-related admissions in the previous year was a common indicator of new short-term admissions. Among patients discharged home at the index ED visit, the presence of high pCO₂ at the index ED visit as well as high levels of fatigue 1 week after the ED visit were prognostic

of readmission, which may have been related to poor control of the index exacerbation. The fact that new visits to the ED within 7 days of the index visit were associated with a higher risk of eCOPD hospital admission within 2 months may be explained by the severity of the exacerbation or inadequate control of the disease. The profile emerging from these data of a patient at a high risk for short-term hospital admission is that of severe baseline COPD where the exacerbation was not properly resolved or controlled, as reflected by the patient's self-reported level of dyspnea. Among patients admitted to the hospital at the index ED visit, the variables associated with short-term admission are those related to greater fatigue during the admission and a higher level of baseline dyspnea, both of which indicate greater severity of a patient's underlying COPD. In this case, the profile is of a patient with a more severe baseline COPD and deterioration in health status during the index admission.

Several studies with designs, methodologies and sample sizes different from ours have found similar and different predictors of eCOPD-related hospital admission. Among those with a prospective design, the predictors identified include: a patient's age [23], clinical characteristics such as previous admissions, FEV₁ and pCO₂ [10, 24–26], the treatments prescribed (e.g. the long-term use of oral corticoids [23, 27]) and symptoms or health-related quality of life parameters such as dyspnea, PA and general health status [12, 25, 27, 28]. As it can be seen, our results share some of these variables but add others recorded during follow-up. Additional parameters identified in other studies were lifestyle habits (e.g. smoking), living status (e.g. in a residence or nursing home and the level of dependence), comorbidities, the need for inhaled corticoids, anticholinergics, antibiotics or long-term home oxygen therapy and the length of stay in hospital [8, 9]. All previously identified parameters were available in our database and were individually tested in our multivariate analysis. However, none had a statistically significant influence on short-term admissions in either of the patient groups that we analyzed.

The strengths of this study are the large sample size, the standardized data collection and the separate evaluation and development of predictive models – for patients admitted to the hospital and those discharged home at the index ED visit – of several parameters that may play a role in new admissions to a hospital after an eCOPD. The parameters identified as predictors of short-term admissions are important, but so is the wide range of variables evaluated and discarded as possible predictors, many of which have been put forth in previous studies. Finally, in our models, we were able to take into account repeated measurements of various health status variables that provide a dynamic view of the evolution of our patients; this more properly reflects clinical thinking.

The limitations of our study should also be noted. First, as is the case for many prospective studies, some data are missing. As noted above, we were able to include a high proportion of patients at follow-up and had complete information for the variables managed in the analysis. Admission of a patient to a hospital is both an objective and subjective decision that is driven by different variables in different institutions. Our models had good AUC results (0.73–0.82) but could be improved.

Several studies have demonstrated the adverse effect that hospital admission has on any patient [8, 28]. In the case of COPD patients, each hospital admission contributes to a deterioration of patient health status, related to worsening of their disease and accompanying comorbid-

ities as well as to the psychological effects that hospital admission has on many patients [29]. Therefore, identifying warning signs related to possible later hospital admission may help establish preventive or therapeutic actions and reduce the number of eCOPD admissions.

In conclusion, our results identify several easily recorded variables that may allow clinicians to identify patients experiencing an eCOPD who are at a higher risk of subsequent hospital admission. Simple questions about the patient's dyspnea level and change in this level over time may alert physicians to high-risk patients. As telemedicine is more frequently being used with patients with chronic diseases such as COPD, checking patients' levels of dyspnea can be easily conducted and can provide an early warning of imminent adverse evolution of the disease. Our results suggest the need for future work to assess whether such early identification and a corresponding therapeutic intervention could prevent eCOPD-related ED visits and hospital admissions, the feasibility of which has already been partially demonstrated by some studies [30].

Appendix

The IRYSS-COPD Group

The group included the following coinvestigators: Dr. Jesús Martínez-Tapias (Dirección Económica, Área Gestión Sanitaria Sur Granada), Alba Ruiz (Hospital de Motril, Granada), Dr. Eduardo Briones and Dr. Silvia Vidal (Unidad de Calidad, Hospital Valme, Sevilla), Dr. Emilio Perea-Milla, Francisco Rivas (Servicio de Epidemiología, Hospital Costa del Sol, Málaga – REDISSEC), Dr. Maximino Redondo (Servicio de Laboratorio, Hospital Costa del Sol, Málaga – REDISSEC), Javier Rodríguez Ruiz (Responsable de Enfermería del Área de Urgencias, Hospital Costa del Sol, Málaga), Dr. Marisa Baré [Epidemiología y Evaluación, Corporació Sanitaria Parc Taulí (CSPT) – REDISSEC, Sabadell], Drs. Manel Lujan, Concepción Montón, Amalia Moreno, Josune Ormaza and Javier Pomares (Servicio de Neumología, CSPT), Dr. Juli Font (Medicina, Servicio de Urgencias, CSPT), Dr. Cristina Estirado and Dr. Joaquín Gea [Servicio de Neumología, Hospital del Mar, Barcelona, 'CIBERES' (CIBER de Enfermedades Respiratorias)], Drs. Elena Andradas, Juan Antonio Blasco, Nerea Fernández de Larrea (Unidad de Evaluación de Tecnologías Sanitarias, Agencia Laín Entralgo, Madrid), Dr. Esther Pulido and Dr. Mikel Sánchez (Servicio de Urgencias, Hospital Galdakao-Usansolo, Bizkaia), Dr. Jose Luis Lobo (Servicio de Neumología, Hospital Txagorritxu, Araba), Dr. Luis Alberto Ruiz (Servicio de Respiratorio, Hospital Cruces, Bizkaia), Dr. Ane Miren Gastaminza (Hospital San Eloy, Bizkaia); Dr. Ramon Agüero (Servicio de Neumología, Hospital Marques de Valdecilla, Santander); Dr. Gabriel Gutiérrez (Servicio de Urgencias, Hospital Cruces, Bizkaia), Dr. Belén Elizalde (Dirección Territorial de Gipuzkoa), Dr. Felipe Aizpuru (Unidad de Investigación, Hospital Txagorritxu, Álava – REDISSEC), Dr. Inmaculada Arostegui (Departamento de Matemática Aplicada, Estadística e Investigación Operativa, UPV – REDISSEC), Amaia Bilbao (Hospital de Basurto

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