1. Title:
Predictors of Early Readmission Among Patients Aged 40 to 64 Years Hospitalized For Chronic Obstructive Pulmonary Disease

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All authors listed above contributed in study design, extraction, analysis, and interpretation of the results, as well as manuscript preparation.

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The risk prediction model on predictors of early readmission among patients 40-64 years old hospitalized with chronic obstructive pulmonary disease (COPD) is lacking. Our results showed that addition of provider and system factors to patient's factors improves the predictive power of the model. Some of these factors are potentially modifiable.

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No data was submitted as online supplement.

ABSTRACT

Rationale: Various causes can contribute to the high rates of readmissions among patients hospitalized with chronic obstructive pulmonary disease (COPD).

Objective: To determine the frequency and predictors of early readmission among patients age 40-64 years, hospitalized with COPD.

Methods: In a retrospective cohort study, using a large national commercial insurance database, we obtained the clinical information within 12 months prior to the index hospitalization and 30 days after discharge.

Measurements: Primary outcome was early readmission, defined as hospitalization within 30 days from discharge. We categorized predictor variables as patient, provider, and system factors and compared these variables between patients readmitted and those not readmitted. Logistic regression was used for multivariable analysis.

Main results: Of 8,263 patients who met the inclusion criteria, 741 (8.9%) had early readmission. Multivariable analysis showed patient factors (male sex, history of heart failure, lung cancer, osteoporosis and depression), provider factors (no prior prescription of statin within 12 months before the index hospitalization and no prescription of short-acting bronchodilator, oral steroid and antibiotic upon discharge) and system factors (length of stay <2 or >5 days and lack of follow-up visit after discharge) were associated with early readmission among patients hospitalized with COPD. C-statistics of the model including patient characteristics was 0.677 (95% Confidence Interval [CI]: 0.656-0.697), which was improved to 0.717 (95%CI: 0.702-0.732), after addition of provider- and system-based factors.

Conclusions: One in 11 patients hospitalized with COPD is readmitted within 30 days after discharge. Provider and system factors are important modifiable risk factors of early readmission.

Keywords: Hospital readmission, COPD, follow-up visit.

INTRODUCTION

In 2009, the Center for Medicare and Medicaid Services (CMS) began to publicly report 30-day risk-standardized readmission rates for pneumonia, congestive heart failure (CHF) and acute myocardial infarction (AMI), as a quality performance measure [1-3]. While some readmissions may be unavoidable, reducing hospital readmissions has been an objective of the Affordable Care Act and Accountable Care Organizations. The readmission reduction program seeks to reduce unnecessary readmissions of patients. One in five Medicare beneficiaries is hospitalized within 30 days from hospital discharge [4], at a cost of more than $15 billion annually [4;5].

High rates of hospital readmissions and unexplained variation in those rates may indicate problems in delivery of care, transitions of care or outpatient management following discharge. Improving the quality of care during care transitions at the time of hospital discharge may result in fewer hospital readmissions and associated costs [6;7]. In 2012, CMS started to reduce Medicare payments to hospitals with high readmission rates for patients admitted with CHF, myocardial infarction, and pneumonia [8]. Starting from fiscal year 2015, this list will also include chronic obstructive pulmonary disease (COPD)[9]. COPD is the third most common cause of hospital readmission among Medicare beneficiaries [4]. Almost one in four (22.6%) Medicare beneficiaries [4] and one in 12 younger adults (40-64 years old)[10] hospitalized for COPD were readmitted to the hospital within 30-days of discharge.

COPD affects more than 6.2% of adults in the United States, is the 3rd most common cause of death [11] and the only leading cause of mortality with rising morbidity and mortality [12;13]. The typical disease course of the COPD patient is punctuated with exacerbations [14-16]. Most are treated in outpatient settings, but more severe cases, however, require hospitalization. Patients are at increased risk of re-exacerbations within the first few weeks of the index exacerbation [17], which can result in hospital readmissions. High rates of readmission among patients with COPD may result from the complexity of the index hospitalization or problems in transition of care or outpatient follow up after discharge [18].

Claim-based models to predict 30-day readmission exists for CHF, AMI and pneumonia [19-22]. However, similar models are lacking for patients hospitalized for COPD. We hypothesized that an array of patient, provider, and system factors contribute to early readmission among patients hospitalized with COPD. In the current work, we aimed to evaluate the frequency of early hospital readmission rate (within 30 days of discharge) for patients 40 to 64 years old hospitalized for COPD and build a risk prediction model based on patient, provider and system factors that were associated with early readmission.

PATIENTS AND METHODS

Study population

The study population included commercially insured patients aged 40 to 64 years old hospitalized with a primary discharge diagnosis of COPD between January 2009 and November 2011 in a large private health insurance plan, which covers approximately 70 million Americans. The Clinformatics™ Data Mart, managed by OPTUMInsight™, is composed of medical and pharmacy claims data for members in this health plan throughout the United States. The Research Database contains claims data from May 2000 to December 2011 for approximately 51,000,000 current and past members, with a mean continuous enrollment period of approximately two years. All files contain encrypted patient and provider identifiers, which permit patient specific longitudinal tracking of patient, hospital and medication histories. However, race and socioeconomic status are not captured in the database.

Using The International Classification of Diseases, Ninth Revision (ICD-9), we included the patients hospitalized between January 2009 and November 2011 with primary diagnoses codes of COPD. We excluded patients 65 years or older as well as those younger than 40 years, those with incomplete data for the 12 months prior to the index hospitalization, those transferred to a long-term facility and those with discharge diagnosis ICD-9 codes of 490 (non-specific bronchitis) and 493 (asthma). Overall, 8263 patients aged 40-64 years, with the ICD-9 codes of 491.xx, 492.xx, and 496 as their primary diagnoses were included in the study (Figure 1). The university Institutional Review Board approved the study protocol.

Variables

The Research Database contains the following components: the member enrollment file, consisting of demographic information on all health plan enrollees (year of birth, gender, state and benefits); medical claims records, including diagnosis and procedure codes from all health care sites (inpatient hospital, emergency room, physician's office or surgery center) for services provided to enrollees; pharmacy claims (drug code, drug names, drug strength, date prescription filled and days of supply).

Predictor variables. Predictor variables were classified as patient, provider and system factors. The patient factors included age, sex and type and number of comorbid conditions prior to the index admission. We examined comorbidities prevalent in this population based on existing literature and also in our cohort (congestive heart failure [CHF], lung cancer, alcohol abuse, obesity, depression, osteoporosis, chronic kidney disease [CKD] [23], diabetes mellitus [DM], hyperlipidemia [HLD] and obstructive sleep apnea [OSA]). We examined the effect of both individual comorbidities, the number of unique comorbidities, and certain combinations.

The provider factors focused on the quality of care within the 12 months prior to hospitalization and the prescriptions given upon discharge. The type of inhaler

medications prescribed within a year before the index hospitalization and any prescription of in-home oxygen were recorded for each subject. COPD medications included any prescription of short-acting beta agonist (SABA), short-acting muscarinic antagonist (SAMA), long-acting beta agonist (LABA), long-acting muscarinic antagonist (LAMA), inhaled corticosteroid (ICS) or oral steroid, from the 12 months prior to the index hospitalization to 30 days after discharge. In addition, we recorded any prescription of antibiotics within 30 days after discharge. To examine the protective effect of statins and/or angiotensin converting enzymes inhibitors (ACE-I) [24] on COPD readmission we recorded any prescription of statins and ACE-I within the 12 months prior to the index hospitalization. Claims for oxygen therapy over the 12 months prior to the index hospitalization and within 30 days of discharge were also recorded.

System factors included number of outpatient visits over 12 months prior to the index hospitalization, type of COPD provider seen (primary care physician [PCP], pulmonary specialist, both PCP and specialist), number of inpatient hospitalizations over the 12 months prior to the index hospitalization, length of stay in the hospital during index hospitalization, discharge follow-up visit, and type of provider seen after discharge. Length of stay during the index hospitalization was categorized as 1-2, 3-4, 5-6 or ≥7 days.

Main outcome. The primary outcome was defined as all-cause readmission within 30 days of the discharge day of index hospitalization. The secondary outcome was the reason for and the factors associated with re-admission.

Statistical analysis

In this retrospective cohort study, we used descriptive statistics to report the characteristics of all cohorts and the rates of re-hospitalization within 30 days by patient, provider and system characteristics. The readmission rates across different levels of each categorical and continuous variable were compared by chi-square (χ^2) and student's t-test, respectively.

Two multivariable logistic regression models were built to determine the independent predictors of early readmission. The first model included baseline patient demographic and clinical characteristics, provider factors (prescriptions over the 12 months prior to index hospitalization) and system factors (type of provider and number of hospitalization within the year prior to index). Then, provider (prescriptions) and system factors (length of stay, discharge follow up and type of provider in the discharge follow up) during hospitalization and within 30-days after discharge were added into the second model. C-statistics with it 95% confidence interval (CI) from the receiving operating curves were calculated. We cross validated the model by splitting the data into derivation and validation cohort. We used SAS version 9.2 (SAS Institute Inc., Cary, NC) for all statistical analyses. All hypotheses testing were 2-sided with significance set at $p \leq 0.05$.

RESULTS

Study population and readmission pattern:

Between January 2009 and November 2011, 8,263 patients aged 40-64 years were hospitalized for COPD. All patients were followed up for 30 days after discharge. Of these, 741 (8.9%) were readmitted within the follow up period. Table 1 presents the baseline characteristics of the entire cohort and those readmitted within 30 days.

Factors Associated With Early Readmission

Univariable analysis

As illustrated in Table 1, patients with a history of CHF, lung cancer, anxiety, obesity, depression, osteoporosis, CKD, DM, HTN, and OSA were more likely to be readmitted within 30 days, compared to those who did not have these co-morbidities. There was a stepwise increase in rates of 30-day readmission with increasing number of comorbid medical conditions. For example, patients with 0, 1, 2 and 3 or more comorbidities had 6.1%, 6.9%, 9.4% and 14.9% rates of readmissions, respectively (p<0.001). In addition, COPD patients with certain combination of comorbidties had much higher risk of readmission than others, suggesting differential role of coexisting comorbidities. For example COPD patients with CHF and osteoporosis (n=74) had the highest risk for readmission (21.0%), followed by those with CHF and anxiety (n=100; 18.2%), CHF and depression (n=83; 15.9%), and CHF and alcohol abuse (n=129; 14.4%).

Patients who were not receiving any COPD medications, Statins or angiotensin converting enzyme inhibitor (ACE-I) in the year prior to hospitalization had higher rates of 30-day readmissions. As expected, patients with severe disease (as suggested by long term oxygen therapy use or being seen by a pulmonary specialist) had higher rates of 30-day readmissions (Table 1). We tested for differential effects of Statins on 30-day readmission in patients with and without hyperlipidemia. Patients receiving Statins for Hyperlipidemia had lower odds of 30-day readmission (OR: 0.57, 95%CI 0.44, 0.75) compared to those patients without hyperlipidemia (OR: 1.13, 95%CI 0.64, 2.00). However, the effect of ACE-Inhibitors on 30-days readmission was not different in patients with or without history of CHF (p=0.06).

Table 2 shows the process of care measures during index hospitalization. As shown, patients who did not receive a prescription of SABA/SAMA, LABA, LAMA or inhaled glucocorticoids within 30 days of discharge had higher rates of readmission. Patients who received any prescription for COPD medications and/or antibiotics had lower rates of 30-day readmission. For example, rates of 30-day readmission were 16.8% in patients who received no prescriptions for COPD medications within 30 days of discharge, compared to 5.6% in those who received prescriptions for any COPD medications (p-value <0.001). Patients who had a follow-up visit within 30 days of discharge had a readmission rate of 7.6%, compared to 10.8% in those who did not have follow-up visit post-discharge (p-value 0.001). There was no statistical difference in rate of readmission in terms of time to follow-up visit since discharge or type of provider seen after discharge.

Table 3 presents the primary reason for each readmission. The most common reason for readmission was COPD (36.7%), followed by respiratory failure (9.1%) and pneumonia (6.2%). Other reasons for readmission were related to cardiovascular comorbidities. Half of the patients were readmitted within the first 15 days and 19% within the first 7 days.

Multivariable analysis

Table 4 presents the multivariable analysis of factors associated with 30-day readmission. As shown, female patients had lower odds of readmission (odds ratio [OR] 0.87, 95% CI 0.68-0.93). The highest odds of readmission were associated with patients with lung cancer co-morbidities (OR 1.63, 95% CI 1.28-2.13). Patients who had a prescription for statins in the 12 months prior to hospitalization had lower odds of readmission (OR 0.64, 95% CI; 0.50-0.71). Prescriptions antibiotics within 30 days of discharge were associated with a lower likelihood of a 30-day readmission (OR 0.75; 95% CI: 0.63-0.89).

Patients with shorter (≤2 days) and longer (≥7 days) stays had increased odds of a 30-day readmission. Patients who had a follow up within 30 days of discharge had lower odds of readmission (OR 0.87: 95% 0.77-0.99) compared to those who did not have a follow-up visit to an outpatient provider post-discharge.

Finally, we examined the c-statistics of the model in predicting 30-day readmission. A model including only the patient characteristics had a c-statistics of 0.677 (95% CI: 0.656-0.697). The addition of provider- and system-level factors post-discharge significantly enhanced the model prediction to 0.717 (95% CI: 0.702-0.732). We cross-validated the final model by randomly splitting the cohort into deviation set and validation set. The C-statistic of validation sample was 0.73, 95%CI of 0.70 to 0.76. In addition, the analysis of assessment of predictive accuracy of our final model indicated that the rate of readmissions was 4.3% for patients with the predicted probability of readmission in the bottom quartile compared to 20.3% for the patients with the predicted probability of readmission in the top quartile. There was 4.7 folders increase in readmission rates between these two groups of patients.

DISCUSSION

One in eleven patients aged 40-64 years hospitalized with COPD were readmitted within 30 days from the index hospitalization. Patient (sex, comorbid conditions), provider (specific medications prescribed) and system (process of care) factors predicted early readmission. To our knowledge, this is the first study to examine potentially modifiable provider- and system- level factors associated with readmission.

The early readmission rate of 8.9% in one among study cohort is similar to a recent study on similar patient population [10]. Prior reports have shown 30-day readmission for patients with COPD to be 14.3-24%[4;25]. Among Medicare beneficiaries, the national readmission rates are much higher [4;5]. Low early readmission rates in one study can be explained by the relatively younger age group and less comorbidities.

In concordance with previous studies the number of comorbidities directly correlates with frequency of 30-day readmission after hospital discharge [26]. Those with conditions such as CHF, lung cancer, anxiety, depression and osteoporosis had higher likelihood of readmission. In patients with chronic debilitating medical conditions, anxiety and depression are common ailments [27]. The prevalence of anxiety and depression is high in the COPD population [28-30], with the risk of depression in those with severe disease nearly 2.5 times higher than normal [30]. Whether the worsening of COPD induces anxiety and depression or a history of anxiety and depression causes lack of adherence to COPD management is unknown. The presence of these psychosocial factors has been associated with increased readmission in COPD patients [31-33]. Patients with anxiety and depression have poor compliance with medications [34;35]. This association further underscores the need to tailor efforts toward proper identification and treatment of anxiety and depression. However, the benefit of treating these psychological conditions in reducing readmission is unknown.

The physician plays a vital role in preventing hospital readmission for COPD. Patients who were prescribed statins in the 12 months prior to admission had lower rates of 30-day readmission. Current interest has focused on the benefit of statins in reducing inflammatory markers that contribute to COPD inflammation [36], specifically with regards to mortality. In the Rotterdam study of statin use in 363 patients with COPD, long term (>2 year) statin use was associated with nearly 40% decreased risk of death compared to no prior use [37]. In a recent cohort study it was shown that statin use in COPD patients led to a 30% reduction in all-cause mortality at 3-4 years after first hospital admission with adjustment for prior history of diabetes and cardiovascular disease [38]. The benefit of statins in reducing all-cause mortality and respiratory-related mortality is shown in several studies[38;39]. The National Heart Lung Blood Institute *(*NHLBI*)* sponsored randomized clinical trial of Simvastatin Therapy for Moderate and Severe COPD (STATCOPE) is currently investigating the effects of statin therapy in patients with COPD. Further studies will need to confirm the benefit of statin therapy in reducing readmissions.

Patients who were prescribed steroids and antibiotics on discharge were less likely to be readmitted within 30 days. The positive effects of steroids in the management of COPD are well demonstrated in randomized clinical trials [40] and administrative data [41]. Patients who are prescribed oral steroids on admission will have faster improvement in FEV1, shorter hospital stays and improvements in patient-assessed dyspnea and quality of life [40;41]. In a retrospective cohort study of patients 40 years or older, Rothberg et al. found that, in patients with COPD, early antibiotic administration was associated with lower rates of readmission and lower rates of inpatient mortality [42]. In a study of over 53,000 patients, Stefan et al. found that, in patients admitted with COPD who were treated with steroids, the addition of antibiotics was associated with a 40% reduction in risk of in-hospital mortality and a 13% improvement in rate of readmission [43]. Despite promising results from both randomized clinical trials and large administrative data on the impact of steroids and antibiotics on COPD exacerbation, not all exacerbations are bacterial and routine use of antibiotics remains controversial.

While modifiable patient and physician factors may reduce the likelihood of readmission, system factors that can be modified should not be overlooked. In our study, we found that those patients with a follow-up visit with either a PCP or pulmonologist had lower rates of readmission. A study of the Medicare population found similar results [44]. Efforts to improve follow-up visits through automated scheduling upon admission or reminder phone calls should be targeted. The efficacy of this intervention was shown in conditions such as CHF [45]. Our results of higher readmission rates for patients with low ($\leq$2 days) or higher ($\geq$7 days) lengths of stay are consistent with a prior study [46]. The observed difference of high readmission rates in type of provider seen over 12-months before index hospitalization could be attributable to selection bias, as sicker patients are more likely to be seen by a pulmonary physician. Patients with too short or too long hospital stay have higher rate of readmission in consistent with prior studies[46;47]. Our results may indicate that patients discharged ≤2 days are undertreated causing earlier readmission. Patients who are admitted ≥5 days may have more severe hospitalizations, refractory disease, or suffer from nosocomial infections causing earlier readmission.

The 30-day readmission risk prediction models for CHF, acute MI, and pneumonia are based on administrative claims and have moderately discriminatory C-statistics and are mostly driven by patient factors [21;22]. Provider and system factors are potentially modifiable and, in our study, adding these factors to patient factors significantly improved the c-statistics of the model to predict 30-day readmission. Future studies should include provider and system factors in risk prediction models.

Our study has several limitations. We used ICD-9 to identify patients hospitalized with COPD. Previous studies suggested low sensitivity of this approach [48]. We repeated the analysis by addition of ICD-9 codes 490 and 493 to the baseline cohort. The 30-day readmission rates were 7.73 and 7.68%, respectively. Utilizing administrative claim data, we do not have information on the severity of patients' COPD or the complexity of the index hospitalization. These factors can confound the rate of

readmission as sicker patients are more likely to be readmitted. Similarly, since our study cohort was limited to ages 40-64 years these results cannot be generalized to fee-for-service Medicare beneficiaries. Socioeconomic status is an important determinant of readmission and was not captured in the database. While the prescription of certain medications is associated with lower readmission rate, the analysis does not take into account adherence to medications. This limitation may underinflate the benefit of steroids, antibiotics and LABA/LAMA as patients who were prescribed these medications, but were non adherent, and then were readmitted within 30 days should be excluded. Finally, using patient, provider and system factors, we were able to build a risk prediction model that was cross validated in the current dataset but needs validation in an independent sample.

In summary, patient, provider and system factors predict COPD readmission. Modifiable provider and system factors should be targeted to decrease the rate of readmission within 30 days.

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FIGURE LEGENDS

Figure 1. Establishment of cohort of patients aged 40 to 64 years and hospitalized between 2009 and 2011 with primary diagnosis of Chronic Obstructive Pulmonary Disease.

Figure 2. Distribution of the early readmission among patients aged 40-64 years hospitalized with COPD between 2009 and 2011.

Table 1. Baseline demographics of patients aged 40-64 years hospitalized for Chronic Obstructive Pulmonary Disease (COPD) and those readmitted within 30-days between 2009 and 2011.

	Total (*n=8263*)	30 day readmission		*p-value*
		No (n=7,522) *n* (%)	Yes (*n*=741) *n* (%)	
PATIENT FACTORS				
Age (mean, SD)	56.55 (5.73)	N/A[¥]	57.02 (5.53)	0.257
Age group (in years)				
40-54	2729	2507 (91.9)	222 (8.1)	0.063
55-64	5534	5015 (90.6)	519 (9.4)	
Sex				
Female	4862	4423 (90.9)	439 (9.1)	0.82
Male	3401	3099 (91.1)	302 (8.9)	
Congestive Heart Failure				
Yes	2066	1797 (86.9)	269 (13.1)	<0.001
No	6197	5725 (92.4)	472 (7.6)	
Lung Cancer				
Yes	347	298 (85.9)	49 (14.1)	0.001
No	7916	7224 (91.3)	692 (8.7)	
Anxiety				
Yes	2206	1947 (88.3)	259 (11.7)	<0.001
No	6057	5575 (92.0)	482 (8.0)	
Alcohol abuse				
Yes	4372	3981 (91.1)	391 (8.9)	0.93
No	3891	3541 (91.0)	350 (9.0)	
Obesity				
Yes	1488	1319 (88.6)	169 (11.4)	0.001
No	6775	6203 (91.6)	572 (8.4)	
Depression				
Yes	811	713 (87.9)	98 (12.1)	0.001
No	7452	6809 (91.4)	643 (8.6)	
Osteoporosis				
Yes	1277	1112 (87.1)	165 (12.9)	<0.001
No	6986	6410 (91.7)	576 (8.3)	
Chronic Kidney Disease				
Yes	468	401 (85.7)	67 (14.3)	<0.001
No	7795	7121 (91.3)	674 (8.7)	
Diabetes mellitus				
Yes	2549	2272 (89.1)	277 (10.9)	<0.001
No	5714	5528 (96.7)	186 (7.3)	
Hypertension				
Yes	5713	5158 (90.3)	555 (9.7)	<0.001
No	2550	2364 (92.7)	186 (7.3)	
Hyperlipidemia				
Yes	4242	3840 (90.5)	402 (9.5)	0.096
No	4021	3682 (91.6)	339 (8.4)	
Obstructive sleep apnea				
Yes	1435	1276 (88.9)	159 (11.1)	0.002
No	6828	6246 (91.5)	582 (8.5)	
Number of comorbidities				
No comorbid conditions	1261	1184 (93.9)	77 (6.1)	<0.001
One comorbidities	3128	2912 (93.1)	216 (6.9)	
Two comorbidities	2328	2110 (90.6)	218 (9.4)	
Three or more comorbidities	1546	1316 (85.1)	230 (14.9)	
PROVIDER FACTORS				
Any COPD medication[*] one year prior to the hospitalization				
Yes	3892	3704 (95.2)	188 (4.8)	<0.001
No	4371	3818 (87.3)	553 (12.7)	
ACE[**] Inhibitors				
Yes	1566	1466 (93.6)	100 (6.4)	<0.001
No	6697	6056 (90.4)	641 (9.6)	
Statins				
Yes	1715	1614 (94.1)	101 (5.9)	<0.001
No	6548	5908 (90.2)	640 (9.8)	
Long-term oxygen therapy (1 year prior to index admit)				
Yes	2032	1769 (87.1)	263 (12.9)	<0.001
No	6231	5753 (92.3)	478 (7.7)	
SYSTEM FACTORS				
Outpatient care in previous 12 months				
Visit to PCP[β]	3215	2921 (90.9)	294 (9.1)	<0.001
Visit to Pulmonary Specialist	659	576 (87.4)	83 (12.6)	
Visit to both PCP and Pulmonary Specialist	1510	1338 (88.6)	172 (11.4)	
No visit to PCP or Specialist	2879	2687 (93.3)	192 (6.7)	
Total outpatient visits in previous 12 months, mean (SD[δ]), days	3.23 (4.0)	N/A	4.18 (4.5)	<0.001
PCP visits only, mean (SD)	2.05 (2.9)	N/A	2.56 (3.7)	<0.001
Pulmonary Specialist only, mean (SD)	0.83 (2.0)	N/A	1.17 (2.3)	0.008
Number of inpatient hospital visits in 12 months prior to index hospitalization, mean (SD)	1.00 (1.1)	N/A	2.01 (2.7)	<0.001

[*] COPD medication: short/long-acting bronchodilators and/or inhaled or oral corticosteroid; [**] ACE: Angiotensin converting enzyme; [β] PCP: Primary care physician; [δ] SD: standard deviation; and [¥] N/A: not applicable.

Table 2. Process of care and predictors of 30-day readmission among the patients age 40-64 years admitted with COPD, 2009-2011.

	Total COPD* admission	Patients with 30 day readmission		*p-value*
		No	Yes	
PROVIDER FACTORS (within 30 days of discharge)				
SABA** and/or SAMA[β]				
Yes	3153	2973 (94.3)	180 (5.7)	<0.001
No	5110	4549 (89.0)	561 (11.0)	
Long Acting Beta Agonist				
Yes	172	164 (95.3)	8 (4.7)	<0.001
No	8091	7358 (90.9)	733 (9.1)	
Long Acting Muscarinic Antagonist				
Yes	1709	1615 (94.5)	94 (5.5)	<0.001
No	6554	5907 ()	647 (9.9)	
Oral glucocorticoids				
Yes	4894	4610 (94.2)	284 (5.8)	<0.001
No	3369	2912 (86.4)	457 (13.6)	
Inhaled glucocorticoids (ICS[†])				
Yes	480	450 (93.7)	30 (6.3)	0.03
No	7783	7072 (90.9)	711 (9.1)	
ICS plus LABA[‡]				
Yes	2078	1965 (94.6)	113 (5.4)	<0.001
No	6185	5557 (89.8)	628 (10.2)	
Theophylline				
Yes	308	286 (92.9)	22 (7.1)	0.25
No	7955	7236 (91.0)	719 (9.0)	
Any COPD medication during 30 days post discharge				
Yes	5807	5479 (94.3)	328 (5.7)	<0.001
No	2456	2043 (83.2)	413 (16.8)	
Any antibiotics during 30 days post index admission				
Yes	4616	4328 (93.8)	288 (6.2)	<0.001
No	3647	3194 (87.6)	453 (12.4)	
LT/OT[δ] (30 days after index admit)				
Yes	2266	2054 (90.6)	212 (9.4)	0.45
No	5997	5468 (91.2)	529 (8.8)	
SYSTEM FACTORS				
Length of stay during index hospitalization, mean (SD[¥]), days	5.1 (14.9)	N/A	5.7 (14.0)	<0.001
Had a follow-up visit within the 30 days	4732	4374 (92.4)	358 (7.6)	<0.001
No follow up within 30 days after discharge	3531	3148 (89.1)	383 (10.9)	

**COPD: Chronic obstructive pulmonary disease; **SABA: Short-acting beta agonist; [β]SAMA: Short-acting muscarinic antagonist; [†]ICS: Inhaled corticosteroid; [‡]LABA: Long-acting beta agonist; [δ]LT/OT: long-term oxygen term; [¥]SD: standard deviation.*

Table 3. Reasons for 30-day readmission among patients discharged with primary discharge diagnosis of Chronic Obstructive Pulmonary Disease (COPD).

Primary reason for readmission	**n (%)**
COPD, non-specific bronchitis or asthma (491,492, 493 and 496)	301 (40.6)
Respiratory Failure (518)	106 (14.3)
Pneumonia (486)	31 (4.2)
Heart Failure (428)	17 (2.3)
Cardiac Dysrhythmia (427)	16 (2.2)
Lung Cancer (162)	13 (1.8)
Symptoms involving respiratory system (786)	14 (1.9)
Coronary Atherosclerosis (414)	15 (2.0)
Acute Pulmonary Heart Disease (415)	7 (0.9)
Septicemia (038)	12 (1.6)
Other	258 (34.8)
Total	**741**

Table 4. Multivariable analysis of factors associated with 30-day readmission among patients aged 40-64 years and admitted for Chronic Obstructive Pulmonary Disease between 2009 and 2011.

Variables			**Odds Ratio (95% CI)**	***p-value***
PATIENT FCTORS				
Age	40-54 years		1.0	0.386
	55-64 years		1.1 (0.9, 12.9)	
Sex	Male		1.0	0.025
	Female		0.9 (0.7, 0.9)	
Congestive heart failure	No		1.0	0.021
	Yes		1.2 (1.0, 1.5)	
Lung Cancer	No		1.0	0.035
	Yes		1.6 (1.3, 2.1)	
Alcohol Abuse	No		1.0	0.457
	Yes		1.1 (0.9, 1.3)	
Obesity	No		1.0	0.407
	Yes		1.1 (0.9 1.4)	
Anxiety	No		1.0	0.003
	Yes		1.5 (1.2, 1.8)	
Depression	No		1.0	0.016
	Yes		1.3 (1.1, 1.8)	
Osteoporosis	No		1.0	0.008
	Yes		1.3 (1.1, 1.6)	
Hypertension	No		1.0	0.507
	Yes		1.1 (0.9, 1.3)	
Chronic kidney disease	No		1.0	0.395
	Yes		1.1 (0.8, 1.5)	
Hyperlipidemia	No		1.0	0.064
	Yes		1.2 (0.9, 1.4)	
Diabetes mellitus	No		1.0	0.816
	Yes		1.0 (0.9, 1.2)	
Obstructive sleep apnea	No		1.0	0.811
	Yes		0.9 (0.8, 1.2)	
PROVIDER FACTORS				
Prescription of ACE* inhibitors 12 months prior to index admission		No	1.0	0.029
		Yes	0.8 (0.6, 0.9)	
Prescription of statins 12 months prior to index admission		No	1.0	<0.001
		Yes	0.6 (0.5, 0.7)	
Being on long-term oxygen treatment 12 months prior to hospitalization		No	1.0	0.344
		Yes	1.1 (0.9, 1.3)	
Prescription of SABA**/SAMAβ within 30-days of discharge		No	1.0	0.021
		Yes	0.8 (0.6, 0.9)	
Prescription of LABAŦ within 30-days of discharge		No	1.0	0.132
		Yes	0.6 (0.3, 1.2)	
Prescription of LAMA‡ within 30-days of discharge		No	1.0	0.159
		Yes	0.8 (0.7, 1.1)	
Prescription of oral steroid within 30-days of discharge		No	1.0	<0.001
		Yes	0.7 (0.5, 0.8)	
Prescription of ICS° within 30-days of discharge		No	1.0	0.456
		Yes	1.0 (0.7, 1.5)	
Prescription of LABA/ICS within 30-days of discharge		No	1.0	0.194

Variables		**Odds Ratio (95% CI)**	***p-value***
	Yes	0.9 (0.7, 1.1)	
Prescription of any antibiotic within 30-days upon discharge	No	1.0	0.001
	Yes	0.8 (0.6, 0.9)	
SYSTEM FACTORS			
Length of stay	*1-2 days vs. 3-4 days*	1.3 (1.0, 1.5)	0.019
Length of stay	*5-6 days vs. 3-4 days*	1.1 (0.8, 1.4)	0.626
Length of stay	*>7 days vs. 3-4 days*	1.2 (1.1, 1.5)	0.010
Hospitalization[¥]	*no vs. ≥3 admissions*	0.4 (0.3, 0.6)	<0.001
Hospitalization	*one vs. ≥3 admissions*	0.6 (0.4, 0.7)	<0.001
Hospitalization	*two vs. ≥3 admissions*	0.7 (0.6, 0.9)	0.021
Follow-up visit within 30-days	No	1.0	<0.001
	Yes	0.7 (0.6, 0.9)	