ORIGINAL RESEARCH

Early and Long-term Outcomes of Older Adults after Acute Care Encounters for Chronic Obstructive Pulmonary Disease Exacerbation

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Abstract

Rationale: Older patients are at high risk of death and rehospitalization after hospitalizations for acute exacerbations of chronic obstructive pulmonary disease (AE-COPD). Emergency department visits comprise a substantial portion of acute care encounters in this patient population. The risks of mortality and repeat acute care encounters, including both hospital readmission and repeat emergency department visits, after AE-COPD among older adults are not well understood.

Objectives: To examine early and long-term rates of death and repeat acute care encounters after hospitalization or emergency department visit for AE-COPD in Medicare fee-for-service beneficiaries and to identify patient characteristics, including medical comorbid conditions, associated with these outcomes.

Methods: A retrospective analysis was conducted using a nationally representative 5% sample of Medicare fee-for-service claims data from the U.S. Centers for Medicare and Medicaid Services to identify Medicare beneficiaries 65 years or older who had an acute care episode for an AE-COPD between January 1, 2006, and December 31, 2010 (n = 52,741). Outcomes of interest were all-cause mortality, repeat acute care encounters for any cause, and repeat acute care encounters for AE-COPD at 30 days, 1 year, and 3 years.

Measurements and Main Results: Acute care encounters, including hospitalizations and emergency department visits for AE-COPD, were associated with substantial subsequent mortality risk, with 4.6, 24.4, and 48.2% dying by 30 days, 1 year, and 3 years, respectively. The risk of repeat hospitalization or emergency department visit was similarly high, with 1 in 4 patients having a repeat acute care encounter within 30 days of discharge, increasing to 9 in 10 in the next 3 years. Several comorbid conditions and other patient factors, including heart failure, malnutrition, dual eligibility for Medicare and Medicaid, and prior supplemental oxygen use, were independently associated with increased risk of repeat acute care encounter.

Conclusions: Repeat hospitalizations and emergency department visits and death are common in older fee-for-service Medicare beneficiaries seen in acute care for AE-COPD. Our results suggest that addressing important comorbid conditions, such as heart failure or malnutrition, and targeting resources to oxygen-dependent or dual Medicare- and Medicaid-eligible patients may help modify these outcomes.

Keywords: health outcomes; chronic obstructive pulmonary disease; Medicare

Chronic obstructive pulmonary disease (COPD) is the third leading cause of death and early rehospitalization among Americans over age 65 years (1). The yearly cost of COPD to Medicare is high, with an estimated $4 billion spent in COPD-related hospitalizations alone (2). Most of this spending is incurred on repeat visits to the emergency department (ED) and rehospitalizations after an acute exacerbation of COPD (AE-COPD) (3–5). For older beneficiaries hospitalized with an AE-COPD, the estimated 30-day all-cause rehospitalization rate is as high as 20 to 23% (6, 7). Given this, Medicare has added AE-COPD to the list of conditions monitored by the Medicare Hospital Readmission Reduction Program in fiscal year 2015 (8). This has incentivized hospitals across the nation to launch programs to decrease rehospitalizations after an AE-COPD. Pivotal to the success of such programs is identifying patient characteristics associated with the risk of repeat hospitalizations and ED visits.

COPD often coexists with multiple chronic comorbid conditions that increase the complexity of care coordination during and after hospitalization for an AE-COPD, thus increasing the risk of repeat ED visits and rehospitalization. Observational studies of older patients with an AE-COPD have described patient characteristics associated with the risk of rehospitalization and death (9–14). However, most studies were conducted in clinical or Medicare Advantage cohorts, not fee-for-service beneficiaries, the target of the Medicare Hospital Readmission Reduction Program. Furthermore, most previous studies have not considered ED visits as index events or as outcomes of interest, although ED visits are common in persons with COPD (15) and are an added source of cost and disease-related burden for patients.

The aims of this study, therefore, are to examine early and long-term rates of death and repeat acute care (AC) encounters—including both hospital readmissions and repeat ED visits—after an AE-COPD in Medicare fee-for-service beneficiaries and to identify patient characteristics, including medical comorbid conditions, associated with these outcomes.

Methods

Data Sources

We used a nationally representative 5% sample of Medicare fee-for-service claims data from 2005 to 2011 from the U.S. Centers for Medicare and Medicaid Services. The data included standard analytic files for inpatient, outpatient, carrier, skilled nursing facility, hospice, and durable medical equipment claims, and the corresponding denominator files. The inpatient files contain institutional claims for facility costs covered under Medicare Part A. The outpatient files contain claims by institutional outpatient providers (e.g., hospital outpatient departments). Available data elements for outpatient, skilled nursing facility, and hospice claims include beneficiary identifiers, beneficiary demographic information, unique patient identifiers, admission and discharge dates, and *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes. The carrier files contain noninstitutional provider claims for services covered under Medicare Part B. Unique patient identifiers, dates of service, and Healthcare Common Procedure Coding System codes are among the variables included in the carrier and durable medical equipment files. The denominator files contain beneficiary identifiers, dates of birth, sex, race/ethnicity, dates of death, and information about program eligibility and enrollment. This study was approved by the institutional review board of the Duke University Health System.

Study Cohort

From inpatient and outpatient files, we identified Medicare beneficiaries 65 years or older who had an AC episode (ED visit or inpatient admission) for an AE-COPD, were discharged alive between January 1, 2006, and December 31, 2010, and were continuously enrolled in Medicare fee-for-service for at least 12 months before the index encounter. We required that patients had continuous Medicare fee-for-service coverage for 12 months after the index discharge unless they died during this period. AE-COPD was defined using ICD-9-CM diagnosis codes 491.x (chronic bronchitis), 492.x (emphysema), or 496.x (chronic airway obstruction) in the primary position on an inpatient claim or an ED visit (revenue center codes 0450–0459 or

0981). A recent study found that the use of these codes to identify AE-COPD had a positive predictive value of 86% and a negative predictive value of 93% (16). If multiple records existed for a patient, the earliest record was selected. The index date was defined as the discharge date from the index hospitalization or ED visit.

Outcomes

Outcomes of interest were all-cause mortality, repeat AC encounters for any cause, and repeat AC encounters for a recurrent AE-COPD at 30 days, 1 year, and 3 years. We determined all-cause mortality on the basis of death dates in the Medicare denominator files. We determined repeat AC encounters on the basis of Medicare inpatient and outpatient claims and restricted recurrent AC encounters for AE-COPD to those occurring at least 14 days after the index date, in keeping with a previous algorithm developed by Mapel and colleagues (13), to avoid counting a single prolonged exacerbation as two. Transfers to or from another hospital did not count as a repeat AC visit.

The follow-up period was up to 3 years after index discharge. Days to events were calculated from the index date. For patients who did not experience an event, we defined a censoring date as the earliest of (1) 30 days, 1 year, or 3 years after discharge, depending on the outcome; (2) the end of the period for which data were available (December 31, 2010); or (3) the date on which the patient's data were no longer available because the patient enrolled in a Medicare Advantage plan.

Covariates

Covariates of interest included patient demographics (age, sex, race/ethnicity, and dual eligibility for Medicare and Medicaid supplemental security income [a surrogate for lower socioeconomic status]), pulmonary comorbid conditions (asthma, pulmonary fibrosis, pulmonary hypertension/heart disease, pneumonia, lung cancer, and continuous positive airway pressure [a surrogate for sleep apnea]), other comorbid conditions (myocardial infarction, heart failure, atrial fibrillation/flutter [17], gastroesophageal reflux disease [GERD], renal disease, any solid organ/hematologic malignancy, diabetes, dementia, major psychiatric disorders, malnutrition, and disability), and indicators of disease and exacerbation severity. Prior

oxygen use, a proxy for hypoxemia, was considered an indicator of disease severity based on the Global Initiative for Chronic Obstructive Lung Disease guidelines (18). Transfer to an intensive care unit (ICU) was considered an indicator of AE-COPD severity. Patient demographics were determined from the Medicare denominator files. All comorbid conditions were ascertained from the Medicare inpatient, outpatient, durable medical equipment, and carrier claims files in the 12 months preceding the index date. We consulted previous studies (19, 20) and used clinical judgment to identify comorbid conditions of interest, as detailed in Table E1 in the online supplement.

Statistical Analysis

We first described baseline characteristics of the study population using frequencies with percentages for categorical variables and medians with interquartile range for continuous variables. We then described observed outcomes. For mortality, we calculated cumulative incidence based on Kaplan-Meier estimates. For repeat AC encounters, we calculated incidence based on estimates from the cumulative incidence function, which accounts for the competing risk of mortality. We categorized all-cause repeat AC encounters using ICD-9-CM codes and Clinical Classifications Software (http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccsfactsheet.jsp).

We estimated the unadjusted and adjusted associations between covariates and outcomes using Cox proportional hazards models. In the unadjusted model, each covariate was the only predictor. In the adjusted model, all other covariates were also included without selection. For all models, significance tests and confidence intervals were based on robust standard errors to account for the clustering of patients by hospital. We reported the estimates and 95% confidence intervals. We used a two-tailed $\alpha = 0.05$ to establish statistical significance. All analyses were performed using SAS version 9.1 (SAS Institute Inc., Cary, NC).

Results

Baseline Characteristics

The study sample consisted of 52,741 fee-for-service Medicare beneficiaries who met the inclusion criteria from 2006 to 2010. The median age was 77 (interquartile range, 71–83) years, about 38% were 80 years or older, more than half were women, and one-fourth were dually eligible for Medicare and Medicaid supplemental security income (Table 1). Less than 5% of patients required ICU-level care during the index encounter. During the year preceding the index visit, more than one-third of patients were prescribed oxygen therapy. The most common comorbid condition was heart failure, followed by pneumonia, diabetes, GERD, and asthma.

Repeat AC Encounters

The cumulative incidence of repeat all-cause or AE-COPD–related AC encounters is described in Table 2. The cumulative incidence of all-cause AC encounters was 25.5, 73.0, and 89.4 per 100 at risk at 30 days, 1 year, and 3 years, respectively. The most common reasons for repeat encounters were respiratory or cardiac conditions (Table 3). Causes of repeat encounters were more varied in older age groups; for example, COPD, pneumonia, respiratory failure, other lower respiratory tract disease, and asthma combined accounted for 40.4% of repeat encounters among those aged 66 to 69 years and 32.2% among those aged 80 years or older.

Table 4 shows the association between covariates of interest and repeat AC encounters. Compared with those aged 65

Table 1. Baseline characteristics of fee-for-service Medicare beneficiaries 65 years or older seen in acute care (emergency department or inpatient admission) for acute exacerbations of chronic obstructive pulmonary disease, 2006–2010 (N = 52,741)

Characteristic	N (%)
Age, median (interquartile range), yr	77 (71–83)
65–69	9,484 (18.0)
70–74	11,524 (21.9)
75–79	11,737 (22.3)
≥80	19,996 (37.9)
Male sex	23,397 (44.4)
Race/ethnicity	
White	47,432 (89.9)
Black	3,554 (6.7)
Other/unknown	1,755 (3.3)
Dual eligibility for Medicare and Medicaid	12,662 (24.0)
Chronic obstructive pulmonary disease severity	
Prior oxygen use	19,692 (37.3)
Intensive care unit during index admission	2,218 (4.2)
Pulmonary comorbid conditions (in the 12 mo before the index date)	
Pneumonia	22,335 (42.3)
Asthma	14,794 (28.1)
Pulmonary hypertension/heart disease	5,816 (11.0)
Lung cancer	2,957 (5.6)
Pulmonary embolism	1,738 (3.3)
Use of continuous positive airway pressure	1,471 (2.8)
Pulmonary fibrosis	604 (1.1)
Nonpulmonary comorbid conditions (in the 12 mo before the index date)	
Heart failure	23,423 (44.4)
Diabetes mellitus	18,637 (35.3)
Gastroesophageal reflux disease	13,826 (26.2)
Atrial arrhythmias	13,612 (25.8)
Any solid organ/hematologic malignancy	9,971 (18.9)
Renal failure	8,983 (17.0)
Dementia	7,425 (14.1)
Acute myocardial infarction (or coronary artery disease)	7,066 (13.4)
Major psychiatric disorders	6,006 (11.4)
Hemiplegia, paraplegia, paralysis, functional disability	3,482 (6.6)
Protein-caloric malnutrition	2,797 (5.3)

Definition of abbreviation: AE-COPD = acute exacerbations of chronic obstructive pulmonary disease. AE-COPD was defined using *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnosis codes 491.x (chronic bronchitis), 492.x (emphysema), or 496.x (chronic airway obstruction) in the primary position on an inpatient claim or an emergency department visit (revenue center codes 0450–0459 or 0981).

Table 2. Cumulative incidence of death and recurrent acute care encounters (emergency department visit or inpatient admission) among fee-for-service Medicare beneficiaries 65 years or older seen in acute care for an acute exacerbation of chronic obstructive pulmonary disease, 2006–2010 (N = 52,741)

Outcome	30 d	1 yr	3 yr
Mortality	2,410 (4.6)	12,866 (24.4)	23,006 (48.2)
All-cause repeat acute care encounter	13,430 (25.5)	38,505 (73.0)	45,852 (89.4)
Acute care encounter for recurrent AE-COPD	1,457 (2.8)	11,912 (22.6)	18,306 (37.3)

Definition of abbreviation: AE-COPD = acute exacerbation of chronic obstructive pulmonary disease. Values were summarized as total number of occurrences and rate (cumulative incidence per 100 at risk). The index date was defined as the discharge date from the index hospitalization or emergency department visit. We treated death as a competing risk of repeat acute care visits for all-cause and recurrent AE-COPD.

to 69 years, beneficiaries aged 80 years or older had 9% higher hazard of all-cause repeat encounters after adjusting for other important covariates. Dual eligibility for Medicare and Medicaid supplemental security income was associated with 19% higher hazard of repeat AC encounters for any cause. Beneficiaries who used oxygen in the preceding year had 21% higher hazard of all-cause repeat AC encounters than those who did not. Overall, comorbid conditions increased the risk of all-cause repeat AC encounters. This risk was increased by 20% or more in those beneficiaries with lung cancer, pulmonary fibrosis, heart failure, or malnutrition, compared with those without these diseases.

Most covariates retained similar associations with the risk of recurrent

AC encounter for AE-COPD. However, beneficiaries aged 80 years or older were 17% less likely to have recurrent AE-COPD than those aged 65 to 69 years. Men were 16% more likely than women to have a recurrent AE-COPD. Beneficiaries who used oxygen in the preceding year had nearly double the hazard of recurrent AE-COPD compared with those who did not. The presence of most pulmonary comorbid conditions, GERD, myocardial infarction, and malnutrition increased the risk of recurrent AE-COPD.

Mortality and Characteristics Associated with Death

A total of 2,410 (cumulative incidence, 4.6 per 100 at risk) patients died within 30 days of the index discharge date. The

cumulative incidence of death at 1 year and 3 years of follow up was 24.4 and 48.2 per 100 at risk, respectively (Table 2). Table 5 shows the association between covariates of interest and risk of death across the entire follow-up period. After controlling for other covariates, we found that increasing age was associated with greater hazard of death. Compared with beneficiaries aged 65 to 69 years, those aged 70 to 74, 75 to 79, and 80 years or older had 20, 41, and 94% higher hazard of death, respectively. Men and dual-eligible beneficiaries had higher risk of death than their counterparts. Beneficiaries who used oxygen in the preceding year were 65% more likely to die than those who did not. Those requiring an ICU stay were 63% more likely to die than those who did not. The risk of death was significantly higher in beneficiaries with comorbid conditions such as lung cancer, pulmonary fibrosis, pneumonia, heart failure, atrial fibrillation, renal disease, chronic liver disease, malnutrition, or dementia. Beneficiaries with known sleep apnea, asthma, GERD, or diabetes had lower risk of death than those without these conditions.

Discussion

In this study of fee-for-service Medicare beneficiaries, we found that the prognosis after an ED visit or hospitalization for AE-COPD was poor. These encounters were associated with substantial subsequent mortality risk, with 4.6, 24.4, and 48.2% dying by 30 days, 1 year, and 3 years, respectively. The risk of repeat AC encounter was similarly high, occurring in 1 in 4 patients within 30 days of discharge and increasing to 9 in 10 in the next 3 years. Although nearly half of these encounters were for conditions that cause respiratory distress, a similar proportion reflected other conditions.

Several nonpulmonary comorbid conditions, especially heart failure and malnutrition, as well as supplemental oxygen use and dual eligibility for Medicare and Medicaid, were associated with repeat encounters. These findings highlight the need to consider overall health status and address factors beyond the AE-COPD that prompted the initial encounters, with emphasis on medical comorbid conditions and socioeconomic barriers to post-AC follow-up care. For example, our findings

Table 3. Reasons for first repeat acute care encounter (emergency department visit or inpatient admission) during the follow-up among fee-for-service Medicare beneficiaries seen in acute care for an acute exacerbation of chronic obstructive pulmonary disease, 2006–2010 by age group (N = 45,852)

Reason	Age Group, yr			
	66–69	70–74	75–79	80+
COPD (AE-COPD)	1,999 (24.4)	2,228 (22.4)	2,180 (21.2)	2,990 (17.2)
Pneumonia	484 (5.9)	699 (7.0)	749 (7.3)	1,380 (7.9)
Congestive heart failure (nonhypertension)	252 (3.1)	399 (4.0)	456 (4.4)	1,021 (5.9)
Respiratory failure	365 (4.4)	429 (4.3)	312 (3.0)	476 (2.7)
Chest pain	289 (3.5)	304 (3.1)	267 (2.6)	420 (2.4)
Other low respiratory disorders	215 (2.6)	274 (2.8)	238 (2.3)	425 (2.4)
Asthma	252 (3.1)	242 (2.4)	231 (2.2)	340 (2.0)
Dysrhythmia	152 (1.9)	212 (2.1)	235 (2.3)	406 (2.3)
Superficial injury	144 (1.8)	168 (1.7)	195 (1.9)	404 (2.3)
Septicemia	132 (1.6)	182 (1.8)	203 (2.0)	376 (2.2)
Urinary tract infection	104 (1.3)	145 (1.5)	180 (1.8)	448 (2.6)
Other	3,817 (46.5)	4,681 (47.0)	5,027 (48.9)	8,725 (50.1)

Definition of abbreviation: AE-COPD = acute exacerbation of chronic obstructive pulmonary disease. Values are summarized as n (%).

Table 4. Patient characteristics associated with repeat acute care encounters (emergency department visit or inpatient admission), for all causes and for recurrent acute exacerbation of chronic obstructive pulmonary disease in fee-for-service Medicare beneficiaries 65 years or older seen in acute care for an acute exacerbation of chronic obstructive pulmonary disease, 2006–2010 (N = 52,741)

Variables	Hazard Ratio (95% CI)*			
	All-Cause Repeat Acute Care Encounter (n = 45,852)		Recurrent AE-COPD (n = 18,306)	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Demographic characteristics				
Age group, yr				
65–69	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
70–74	1.00 (0.97–1.04)	0.99 (0.96–1.02)	0.93 (0.88–0.98)	0.93 (0.89–0.99)
75–79	1.07 (1.04–1.11)	1.03 (1.00–1.06)	0.94 (0.89–0.99)	0.95 (0.90–1.01)
≥80	1.17 (1.14–1.21)	1.09 (1.05–1.12)	0.78 (0.74–0.82)	0.83 (0.79–0.87)
Male sex	1.02 (1.00–1.04)	1.03 (1.01–1.05)	1.08 (1.05–1.12)	1.16 (1.12–1.21)
Race				
Black	1.17 (1.12–1.21)	1.09 (1.05–1.14)	1.10 (1.03–1.18)	1.07 (1.00–1.15)
White				
Dual eligibility Medicare and Medicaid	1.25 (1.22–1.28)	1.19 (1.16–1.22)	1.25 (1.21–1.31)	1.25 (1.20–1.30)
Chronic obstructive pulmonary disease severity				
Long-term oxygen use	1.31 (1.29–1.34)	1.21 (1.19–1.24)	2.07 (2.00–2.15)	1.96 (1.89–2.04)
Intensive care unit on index admission	1.15 (1.09–1.21)	1.03 (0.98–1.08)	1.17 (1.07–1.28)	1.05 (0.96–1.15)
Pulmonary comorbid conditions in the 12 mo before the index date				
Pneumonia	1.25 (1.23–1.28)	1.06 (1.03–1.08)	1.28 (1.24–1.33)	1.15 (1.11–1.20)
Asthma	1.15 (1.13–1.18)	1.08 (1.05–1.10)	1.27 (1.22–1.32)	1.17 (1.13–1.22)
Pulmonary hypertension/heart disease	1.31 (1.27–1.35)	1.06 (1.02–1.09)	1.37 (1.30–1.45)	1.12 (1.06–1.18)
Lung cancer	1.34 (1.28–1.40)	1.20 (1.14–1.26)	1.36 (1.26–1.47)	1.25 (1.14–1.37)
Pulmonary embolism	1.28 (1.21–1.35)	1.05 (0.99–1.11)	1.10 (0.99–1.21)	0.96 (0.86–1.06)
Use of continuous positive airway pressure	1.11 (1.05–1.18)	1.00 (0.94–1.06)	0.87 (0.78–0.97)	0.72 (0.64–0.81)
Pulmonary fibrosis	1.39 (1.28–1.51)	1.24 (1.13–1.35)	1.29 (1.09–1.52)	1.04 (0.88–1.23)
Nonpulmonary comorbid conditions in the 12 mo before the index date				
Heart failure	1.52 (1.49–1.55)	1.23 (1.20–1.26)	1.20 (1.16–1.24)	1.06 (1.01–1.10)
Diabetes mellitus	1.23 (1.21–1.26)	1.08 (1.06–1.10)	1.04 (1.00–1.08)	0.96 (0.92–1.00)
Gastroesophageal reflux disease	1.25 (1.22–1.28)	1.13 (1.11–1.16)	1.24 (1.19–1.29)	1.14 (1.10–1.19)
Atrial fibrillation/flutter	1.37 (1.34–1.40)	1.15 (1.12–1.18)	1.03 (0.99–1.07)	0.95 (0.91–1.00)
Any malignancy	1.20 (1.17–1.23)	1.09 (1.05–1.12)	1.05 (1.00–1.10)	0.93 (0.88–0.98)
Renal failure	1.45 (1.41–1.48)	1.16 (1.13–1.20)	1.00 (0.95–1.05)	0.91 (0.86–0.96)
Dementia	1.34 (1.30–1.38)	1.12 (1.08–1.16)	0.90 (0.85–0.95)	0.92 (0.86–0.98)
Acute myocardial infarction	1.41 (1.37–1.45)	1.17 (1.14–1.21)	1.26 (1.20–1.32)	1.15 (1.09–1.21)
Major psychiatric disorders	1.34 (1.30–1.38)	1.15 (1.11–1.18)	1.08 (1.02–1.14)	1.05 (0.99–1.11)
Spinal cord or brain injury induced disability	1.37 (1.32–1.43)	1.13 (1.08–1.17)	0.97 (0.90–1.05)	0.94 (0.87–1.02)
Protein-calorie malnutrition	1.54 (1.48–1.61)	1.21 (1.15–1.26)	1.32 (1.22–1.43)	1.15 (1.06–1.25)

Definition of abbreviations: AE-COPD = acute exacerbation of chronic obstructive pulmonary disease; CI = confidence interval.
*Hazard ratios are derived from Cox proportional hazard models with each covariate as the only predictor in the unadjusted models. The adjusted model included all covariates in the table.

suggest that health systems interested in developing postdischarge services to reduce avoidable readmissions associated with COPD may do well to include protocols that address comorbid conditions and target limited resources to those with economic needs or who require supplemental oxygen.

The early and long-term mortality rates reported here are comparable to previous reports on patients hospitalized for an AE-COPD (1-year mortality, 23–36%) (21–25). Although mortality among patients with COPD who have not had an AE-COPD has not been well studied, 1-year mortality among all patients with COPD aged 65 years or older (regardless of exacerbation history) may be as low as 3 to 4%, even for those with moderate to severe airflow obstruction (26). Our findings highlight the prognostic significance of age and comorbid conditions on the risk of death in this population. Patient characteristics associated with mortality in this study aligned with previous reports based on clinical data: older age, comorbid conditions (especially cardiovascular disease, diabetes, pulmonary vascular disease [25, 27], severe malnutrition [20], and lung cancer), exacerbations requiring ICU admission, and long-term oxygen use (10, 28) were all associated with increased risk of mortality. Although age and disease severity may not be directly modifiable, identifying these high-risk patients and potentially treatable

Table 5. Patient characteristics associated with death from any cause for fee-for-service Medicare beneficiaries 65 years or older seen in acute care (emergency department visit or inpatient admission) for an acute exacerbation of chronic obstructive pulmonary disease, 2006–2010 (N = 52,741)

Variables	Hazard Ratio (95% CI)*	
	Mortality (*n = 23,006*)	
	Unadjusted	Adjusted
Demographic characteristics		
Age group (65–69 reference), yr		
70–74	1.26 (1.18–1.35)	1.20 (1.12–1.28)
75–79	1.55 (1.46–1.65)	1.41 (1.32–1.50)
80 or older	2.25 (2.13–2.38)	1.94 (1.83–2.05)
Male sex	1.22 (1.18–1.26)	1.22 (1.18–1.26)
Race (white reference)		
Black	0.94 (0.87–1.00)	0.95 (0.89–1.02)
Dual eligibility Medicare and Medicaid	1.05 (1.01–1.09)	1.09 (1.04–1.14)
Chronic obstructive pulmonary disease severity		
Long-term oxygen use	1.81 (1.75–1.87)	1.65 (1.59–1.71)
Intensive care unit on index admission	1.88 (1.75–2.02)	1.63 (1.52–1.76)
Pulmonary comorbid conditions in the 12 mo before the index date		
Pneumonia	1.58 (1.53–1.64)	1.15 (1.10–1.19)
Asthma	0.88 (0.84–0.91)	0.83 (0.80–0.86)
Pulmonary hypertension/heart disease	1.65 (1.57–1.73)	1.20 (1.14–1.26)
Lung cancer	2.78 (2.63–2.93)	2.29 (2.12–2.46)
Pulmonary embolism	1.51 (1.39–1.65)	1.09 (1.00–1.19)
Use of continuous positive airway pressure	0.69 (0.61–0.77)	0.66 (0.58–0.74)
Pulmonary fibrosis	2.00 (1.77–2.27)	1.62 (1.42–1.85)
Nonpulmonary comorbid conditions in the 12 mo before the index date		
Heart failure	1.96 (1.89–2.03)	1.40 (1.35–1.46)
Diabetes mellitus	1.09 (1.06–1.13)	0.93 (0.90–0.97)
Gastroesophageal reflux disease	1.03 (0.99–1.07)	0.91 (0.87–0.95)
Atrial fibrillation/flutter	1.69 (1.63–1.75)	1.17 (1.12–1.21)
Any malignancy	1.72 (1.66–1.79)	1.18 (1.12–1.24)
Renal failure	1.73 (1.67–1.81)	1.25 (1.19–1.31)
Dementia	1.94 (1.86–2.02)	1.50 (1.43–1.58)
Acute myocardial infarction or coronary artery disease	1.37 (1.31–1.44)	1.05 (1.00–1.10)
Major psychiatric disorders	1.46 (1.39–1.53)	1.15 (1.09–1.21)
Spinal cord or brain injury induced disability	1.61 (1.52–1.70)	1.22 (1.14–1.30)
Protein-calorie malnutrition	2.54 (2.40–2.69)	1.71 (1.60–1.82)

Definition of abbreviation: CI = confidence interval.
*Hazard ratios are derived from Cox proportional hazard models with each covariate as the only predictor in the unadjusted models. The adjusted model included all covariates in the table.

comorbid conditions may contribute to reducing overall mortality risk among patients with COPD.

Repeat AC visits represent a disruptive, expensive, and potentially preventable adverse outcome. Previous studies of older Americans hospitalized for an AE-COPD report 20 to 23% rates of 30-day all-cause rehospitalization (6, 7, 14, 17, 29). Our slightly higher rates may reflect our broader definition of both index and recurrent events, grouping patients treated and released from the ED with those requiring inpatient stays rather than hospitalized patients alone. Up to 30% of repeat AC

visits in our study were to the ED without leading to inpatient hospitalization. Capturing rates of repeat AC encounters, whether to the ED or as an inpatient stay, may offer a more complete reflection of healthcare use among older adults with COPD. The rate of COPD-specific repeat AC encounters was somewhat lower in older age groups. This reflects in part a higher rate of repeat encounters for other causes, such as heart failure, but also may suggest the possibility of milder COPD severity in patients reaching older age—a possibility that cannot be confirmed in our data.

To our knowledge, this is one of the largest cohort studies describing associations between patient characteristics and repeat AC visits in older U.S. adults seen in the ED or hospital setting for an AE-COPD. A systematic review by Bahadori and FitzGerald (30) summarized predictors of all-cause rehospitalization (not combined hospitalization and ED visits) after admission for COPD. All included studies were conducted outside the United States and used clinical instead of administrative data. Similar to our analysis, age did not predict rehospitalization, whereas long-term oxygen use consistently did.

A previous analysis by Sharma and colleagues (14) of older Medicare fee-for-service beneficiaries hospitalized for COPD found lower risk of repeat AC visits associated with early outpatient follow-up. Shah and colleagues (7) have recently demonstrated higher risk of all-cause readmission after hospitalization for AE-COPD associated with older age, higher overall burden of comorbid conditions, and dual eligibility, among other factors. As in the current study, COPD was the most frequent single cause for readmission but accounted for less than half of all readmissions. Contrary to these prior studies, our analysis considered both ED visits and inpatient stays as index events and outcomes, thus providing a more complete illustration of the burden of recurrent AC use in this population.

This is also the first study exploring the independent associations of specific comorbid conditions and surrogate markers for disease and exacerbation severity with the risks of mortality and repeat AC visits in a Medicare fee-for-service population. One previous study by McGhan and colleagues (21) using Veteran Affairs claims data explored the association of specific comorbid conditions with rehospitalizations but focused exclusively on COPD-related rather than all-cause readmissions. Similar to our findings, pulmonary hypertension and asthma were associated with a higher risk (21). Shah and colleagues (7) reported significantly higher prevalence of several comorbid conditions, particularly heart failure and renal disease, among patients readmitted after hospitalization for AE-COPD.

Compared with most previous studies of hospitalized patients with AE-COPD, our cohort had higher prevalence of comorbid

heart failure (31–33), diabetes, asthma, and GERD (4, 9). Heart failure was the most prevalent comorbid condition and was strongly associated with risk of all-cause repeat AC visit, in keeping with previous reports (34). Several other important comorbid conditions, including asthma, pulmonary hypertension, GERD, myocardial infarction, and malnutrition were also independently associated with a higher risk of recurrent AE-COPD. Compared with patients with either asthma or COPD, patients with both have higher rates of recurrent exacerbations, disability, poor quality of life, and overall healthcare use (35, 36). GERD symptoms are reported often in patients who experience frequent AE-COPD (37). The fact that half of readmissions were for conditions that cause respiratory distress highlights the challenges of initial diagnosis and treatment among patients who present with dyspnea and the importance of addressing both pulmonary and cardiac comorbid conditions. To the extent that these comorbid conditions are modifiable, drawing increased attention to them may help improve outcomes in this complex patient population.

The results of this analysis may be influenced by several limitations. First, this was a retrospective and observational analysis. Second, we relied on ICD-9-CM diagnosis codes from Medicare claims data, not clinical data, to identify AE-COPD events and comorbid conditions and cannot account for some clinical variables and unmeasured variables that are likely to be associated with outcomes. For example, we were unable to use spirometry either to corroborate a diagnosis of COPD or to assess disease severity. AE-COPD can be difficult to distinguish from pneumonia or other causes of respiratory failure using claims data, and claims data are an imprecise indicator of the true presence or absence of many chronic conditions. Nonetheless, the data provide useful information about which conditions were being actively treated and robust assessments of mortality and risk of all-cause repeat AC visits. Third, findings from this study may not generalize to all patients with AE-COPD, especially those treated for an index AE-COPD event in the outpatient setting. However, because the analysis included all Medicare fee-for-service beneficiaries who were seen in AC for AE-COPD, the findings

are representative of a large population of patients with relevance for clinicians and policy makers alike.

Conclusions

Repeat AC encounters and death are common in older fee-for-service Medicare beneficiaries seen in the ED or hospitalized with an AE-COPD. Our results suggest several target populations for interventions that may modify these outcomes: (1) patients with comorbid conditions, such as heart failure or malnutrition, which could be contributing both to symptoms or impairment during the index visit and to subsequent events; (2) patients with dual eligibility for Medicare and Medicaid, who may have socioeconomic barriers that impact transitional and follow-up care; and (3) patients with greater underlying disease severity, such as those requiring home oxygen. Further studies are needed to identify interventions that improve outcomes among these high-risk older patients with COPD. ■

References

1 American Lung Association. Trends in COPD (chronic bronchitis and emphysema): morbidity and mortality. Chicago, IL: American Lung Association. 2013 Mar [accessed 2015 Jan 20]. Available from: http://www.lung.org/assets/documents/research/copd-trend-report.pdf.

2 Torio CM, Andrews RM. National inpatient hospital costs: the most expensive conditions by payer, 2011. Rockville, MD: Agency for Healthcare Research and Quality. 2013 Aug [accessed 2015 Jan 20]. HCUP Statistical Brief #160. Available from: http://www.hcup-us.ahrq.gov/reports/statbriefs/sb160.jsp

3 Centers for Medicare and Medicaid Services. Chronic conditions among Medicare beneficiaries, chartbook, 2012 edition. Baltimore, MD: Centers for Medicare and Medicaid Services; [accessed 2015 Jan 20]. Available from: http://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Chronic-Conditions/Downloads/2012Chartbook.pdf

4 Menzin J, Boulanger L, Marton J, Guadagno L, Dastani H, Dirani R, Phillips A, Shah H. The economic burden of chronic obstructive pulmonary disease (COPD) in a U.S. Medicare population. *Respir Med* 2008;102:1248–1256.

5 Puhan MA, Scharplatz M, Troosters T, Steurer J. Respiratory rehabilitation after acute exacerbation of COPD may reduce risk for readmission and mortality: a systematic review. *Respir Res* 2005;6:54.

6 Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. *N Engl J Med* 2009;360:1418–1428.

7 Shah T, Churpek MM, Coca Perraillon M, Konetzka RT. Understanding why COPD patients get readmitted: a large national study to delineate the Medicare population for the readmissions penalty expansion. *Chest* 2015;147:1219–1226.

8 Centers for Medicare and Medicaid Services. Readmissions reduction program. Baltimore, MD: Centers for Medicare and Medicaid Services. 2014 Aug 4 [accessed 2015 Jan 20]. Available from: http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html

9 Divo M, Cote C, de Torres JP, Casanova C, Marin JM, Pinto-Plata V, Zulueta J, Cabrera C, Zagaceta J, Hunninghake G, et al.; BODE Collaborative Group. Comorbidities and risk of mortality in patients with chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2012;186:155–161.

10 Singanayagam A, Schembri S, Chalmers JD. Predictors of mortality in hospitalized adults with acute exacerbation of chronic obstructive pulmonary disease. *Ann Am Thorac Soc* 2013;10:81–89.

11 Austin PC, Stanbrook MB, Anderson GM, Newman A, Gershon AS. Comparative ability of comorbidity classification methods for administrative data to predict outcomes in patients with chronic obstructive pulmonary disease. *Ann Epidemiol* 2012;22:881–887.

12 Pasquale MK, Sun SX, Song F, Hartnett HJ, Stemkowski SA. Impact of exacerbations on health care cost and resource utilization in chronic obstructive pulmonary disease patients with chronic bronchitis from a predominantly Medicare population. *Int J Chron Obstruct Pulmon Dis* 2012;7:757–764.

13 Mapel DW, Dutro MP, Marton JP, Woodruff K, Make B. Identifying and characterizing COPD patients in US managed care: a retrospective, cross-sectional analysis of administrative claims data. *BMC Health Serv Res* 2011;11:43.

14 Sharma G, Kuo YF, Freeman JL, Zhang DD, Goodwin JS. Outpatient follow-up visit and 30-day emergency department visit and readmission in patients hospitalized for chronic obstructive pulmonary disease. *Arch Intern Med* 2010;170:1664–1670.

15 Tsai CL, Delclos GL, Camargo CA Jr. Emergency department case volume and patient outcomes in acute exacerbations of chronic obstructive pulmonary disease. *Acad Emerg Med* 2012;19:656–663.

16 Stein BD, Bautista A, Schumock GT, Lee TA, Charbeneau JT, Lauderdale DS, Naureckas ET, Meltzer DO, Krishnan JA. The validity of International Classification of Diseases, Ninth Revision, Clinical Modification diagnosis codes for identifying patients hospitalized for COPD exacerbations. *Chest* 2012;141:87–93.

17 Elixhauser A, Au DH, Podulka J. Readmissions for chronic obstructive pulmonary disease, 2008. Rockville, MD: Agency for Healthcare Research and Quality. 2011 Sep [accessed 2015 Jan 20]. HCUP Statistical Brief #121. Available from: http://www.hcup-us.ahrq.gov/reports/statbriefs/sb121.pdf

18 Vestbo J, Hurd SS, Agustí AG, Jones PW, Vogelmeier C, Anzueto A, Barnes PJ, Fabbri LM, Martinez FJ, Nishimura M, *et al*. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary. *Am J Respir Crit Care Med* 2013;187:347–365.

19 Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, Saunders LD, Beck CA, Feasby TE, Ghali WA. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care* 2005;43:1130–1139.

20 Birman-Deych E, Waterman AD, Yan Y, Nilasena DS, Radford MJ, Gage BF. Accuracy of ICD-9-CM codes for identifying cardiovascular and stroke risk factors. *Med Care* 2005;43:480–485.

21 McGhan R, Radcliff T, Fish R, Sutherland ER, Welsh C, Make B. Predictors of rehospitalization and death after a severe exacerbation of COPD. *Chest* 2007;132:1748–1755.

22 Ranieri P, Bianchetti A, Margiotta A, Virgillo A, Clini EM, Trabucchi M. Predictors of 6-month mortality in elderly patients with mild chronic obstructive pulmonary disease discharged from a medical ward after acute nonacidotic exacerbation. *J Am Geriatr Soc* 2008;56:909–913.

23 Connolly MJ, Lowe D, Anstey K, Hosker HS, Pearson MG, Roberts CM; British Thoracic Society and the Royal College of Physicians Clinical Effectiveness Evaluation Unit (CEEu). Admissions to hospital with exacerbations of chronic obstructive pulmonary disease: effect of age related factors and service organisation. *Thorax* 2006;61:843–848.

24 Yohannes AM, Baldwin RC, Connolly MJ. Predictors of 1-year mortality in patients discharged from hospital following acute exacerbation of chronic obstructive pulmonary disease. *Age Ageing* 2005;34:491–496.

25 Groenewegen KH, Schols AM, Wouters EF. Mortality and mortality-related factors after hospitalization for acute exacerbation of COPD. *Chest* 2003;124:459–467.

26 Shavelle RM, Paculdo DR, Kush SJ, Mannino DM, Strauss DJ. Life expectancy and years of life lost in chronic obstructive pulmonary disease: findings from the NHANES III follow-up study. *Int J Chron Obstruct Pulmon Dis* 2009;4:137–148.

27 Tabak YP, Sun X, Johannes RS, Hyde L, Shorr AF, Lindenauer PK. Development and validation of a mortality risk-adjustment model for patients hospitalized for exacerbations of chronic obstructive pulmonary disease. *Med Care* 2013;51:597–605.

28 Miller J, Edwards LD, Agustí A, Bakke P, Calverley PM, Celli B, Coxson HO, Crim C, Lomas DA, Miller BE, *et al*.; Evaluation of COPD Longitudinally to Identify Predictive Surrogate Endpoints (ECLIPSE) Investigators. Comorbidity, systemic inflammation and outcomes in the ECLIPSE cohort. *Respir Med* 2013;107:1376–1384.

29 Hines AL, Barrett ML, Jiang HJ, Steiner CA. Conditions with the largest number of adult hospital readmissions by payer, 2011. Rockville, MD: Agency for Healthcare Research and Quality. 2014 Apr [accessed 2015 Jan 20]. Available from: http://www.hcup-us.ahrq.gov/reports/statbriefs/sb172-Conditions-Readmissions-Payer.jsp

30 Bahadori K, FitzGerald JM. Risk factors of hospitalization and readmission of patients with COPD exacerbation–systematic review. *Int J Chron Obstruct Pulmon Dis* 2007;2:241–251.

31 Hurst JR, Vestbo J, Anzueto A, Locantore N, Müllerova H, Tal-Singer R, Miller B, Lomas DA, Agusti A, Macnee W, *et al*.; Evaluation of COPD Longitudinally to Identify Predictive Surrogate Endpoints (ECLIPSE) Investigators. Susceptibility to exacerbation in chronic obstructive pulmonary disease. *N Engl J Med* 2010;363:1128–1138.

32 Ahluwalia SC, Gross CP, Chaudhry SI, Leo-Summers L, Van Ness PH, Fried TR. Change in comorbidity prevalence with advancing age among persons with heart failure. *J Gen Intern Med* 2011;26:1145–1151.

33 Hawkins NM, Petrie MC, Jhund PS, Chalmers GW, Dunn FG, McMurray JJ. Heart failure and chronic obstructive pulmonary disease: diagnostic pitfalls and epidemiology. *Eur J Heart Fail* 2009;11:130–139.

34 Sharif R, Parekh TM, Pierson KS, Kuo YF, Sharma G. Predictors of early readmission among patients 40 to 64 years of age hospitalized for chronic obstructive pulmonary disease. *Ann Am Thorac Soc* 2014;11:685–694.

35 de Marco R, Pesce G, Marcon A, Accordini S, Antonicelli L, Bugiani M, Casali L, Ferrari M, Nicolini G, Panico MG, *et al*. The coexistence of asthma and chronic obstructive pulmonary disease (COPD): prevalence and risk factors in young, middle-aged and elderly people from the general population. *Plos One* 2013;8:e62985.

36 Gibson PG, Simpson JL. The overlap syndrome of asthma and COPD: what are its features and how important is it? *Thorax* 2009;64:728–735.

37 Falk JA, Kadiev S, Criner GJ, Scharf SM, Minai OA, Diaz P. Cardiac disease in chronic obstructive pulmonary disease. *Proc Am Thorac Soc* 2008;5:543–548.