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New Episodes of Depression among Medicare Beneficiaries with Chronic Obstructive Pulmonary Disease:

Depression Following COPD Diagnosis

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Abstract

Objectives—Depression is a common comorbidity of Chronic Obstructive Pulmonary Disease (COPD) and is associated with increased exacerbations, healthcare utilization, and mortality. Among Medicare beneficiaries newly diagnosed with COPD, the objectives of this study were to: 1) Estimate the rate of new episodes of depression; and 2) Identify factors associated with depression.

Methods—We identified beneficiaries with a first diagnosis of COPD during 2006-2012 using a 5% random sample of Medicare administrative claims data by searching for ICD-9-CM codes 490, 491.x, 492.x, 494.x, or 496. We identified episodes of depression using ICD-9-CM codes 296.2x, 296.3x, and 311.xx. We calculated incidence rates and their 95% confidence intervals (95% CI) and used a discrete time analysis to identify factors associated with development of depression.

Results—Between 2006-2012, 125,348 beneficiaries meeting inclusion criteria were newly diagnosed with COPD. Twenty-three percent developed depression following COPD diagnosis. The annualized incidence rate of depression per 100 beneficiaries following COPD diagnosis was 9.4 (95% CI 9.3, 9.5). Rates were highest in the first two months following COPD diagnosis. COPD diagnosis was associated with increased risk of depression (risk ratio (RR) 1.76; 95% CI 1.73, 1.79) as were COPD-related hospitalizations (RR 4.59; 95% CI 4.09, 5.15), a measure of COPD severity.

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The authors declare no conflicts of interest.

Conclusions—Diagnosis of COPD increases the risk of depression. This study will aid in the allocation of resources to monitor and provide support for individuals with COPD at high risk of developing depression.

Keywords

Chronic Obstructive Pulmonary Disease; Depression; Medicare Beneficiaries

Introduction

Chronic obstructive pulmonary disease (COPD) is a progressive disease characterized by airflow limitation and symptoms including cough and dyspnea. As the third leading cause of death in the United States, COPD affects 12% of Medicare beneficiaries and results in increased healthcare costs and utilization.(Centers for Medicare and Medicaid Services, 2012; Menzin *et al*, 2007; Mannino and Braman, 2007; Hoyert *et al*., 2012; Mapel *et al*., 2000; Barnes and Celli, 2009). Medicare beneficiaries with COPD are more likely to have other comorbid conditions compared to those without COPD.(Mannino and Braman, 2007; Mapel *et al*., 2000; Barnes and Celli, 2009; Sin *et al*., 2006) One of the most common but least-treated comorbidities of COPD is depression, with prevalence ranging from 17% - 44% and evidence that suggests more severe respiratory illness associated with greater depressive symptoms.(Omachi *et al*., 2009; Jennings *et al*., 2009; Fan *et al*., 2007; Ng *et al*., 2007; Di Marcoa *et al*., 2006; van Mannen e*t al*., 2002; Maurer *et al*., 2008) Depression concurrent with COPD is associated with increased exacerbations, healthcare utilization, and mortality, even after controlling for COPD severity.(Omachi *et al*., 2009; Jennings *et al*., 2009; Fan *et al*., 2007; Ng *et al*., 2007; Qian *et al*., 2014) Furthermore, depression may decrease adherence to COPD maintenance medications, resulting in increased hospitalizations and healthcare costs.(Qian *et al*., 2014; Simoni-Wastila *et al*., 2012; Stuart *et al*., 2010)

Prior studies evaluating the association between COPD and prevalence of depression were inconclusive, possibly due to lack of statistical power. (VanEde *et al*., 1999) In a 1999 systematic review, a post-hoc analysis of a study with calculated power of > 80% reported a positive association between COPD and depression. (VanEde *et al*., 1999) A more recent study reported a significant association between COPD and depression among individuals with severe, but not moderate or mild COPD.(van Mannen *et al*., 2002) Omachi and colleagues (2009) conducted a large matched cohort study among younger COPD patients and reported a positive dose-response relationship between COPD severity and prevalence of depression.(Omachi *et al*., 2009)

Most prior studies have focused on the prevalence of depression among individuals with COPD rather than rates of new episodes of depression following COPD diagnosis.(Omachi *et al*., 2009; van Mannen *et al*., 2002; VanEde *et al*., 1999) Information on the risk of depression among individuals recently diagnosed with COPD will aid in allocating resources toward depression screening and treatment and raise awareness among healthcare providers to assess their patient with respiratory disorders for depression.

The objectives of this study were to: 1) Estimate the rate of new episodes of depression following COPD diagnosis; and 2) Identify factors associated with the development of depression among Medicare beneficiaries diagnosed with COPD.

Methods

Study Population

Medicare administrative claims data obtained from the Centers for Medicare & Medicaid Services (CMS) Chronic Condition Data Warehouse (CCW) were the primary source of data for this study. From a 5% random sample from the 2006-2012 CCW data, we identified beneficiaries with at least one inpatient or outpatient claim containing the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) for COPD (490, 491.x, 492.x, 494.x, or 496). We excluded beneficiaries with a history of respiratory cancer, tuberculosis, asbestosis, and sarcoidosis because they may differ from other beneficiaries with COPD in terms of development of depression. To ensure that we captured the majority of claims required to define depression, we required continuous Medicare Parts A, B, D, and no Part C coverage for 10 out of each 12 months of follow-up time. We defined the COPD index date as the date of first diagnosis of COPD occurring within the study period. All Medicare beneficiaries who met criteria for COPD since 1999 have the date of first diagnosis of COPD reported in their administrative claims. We used this date to exclude beneficiaries whose first diagnosis of COPD occurred prior to the study period.

Outcome

We identified beneficiaries with depression by searching for ICD-9-CM codes 296.2x, 296.3x, and 311.xx on one or more inpatient claims, two or more outpatient claims, or one outpatient claim combined with one or more antidepressant prescription fills during the study period. Information on antidepressant fills was collected from Part D prescription drug event files. These ICD-9-CM codes have been used in other studies and are intended to ensure omission of bipolar and related mood disorders in which antidepressants are not recommended treatment.(Frayne *et al.*, 2010; Kramer *et al.*, 2003; Smith *et al.*, 2009) Because depression tends to be under-recorded, we also allowed for evidence of at least one antidepressant prescription fill in conjunction with one outpatient diagnosis of depression. Incident depression was defined as a new episode of depression that occurred during the study period. Depression can be a chronic disorder but also occurs as unique episodes. (Keller *et al.*, 1992; American Psychiatric Association, 2013; Solomon *et al.*, 1997) Therefore, in study subjects with depression episodes both pre- and post-COPD, we required more than 5 months between the diagnoses to ensure that they represented new episodes. If there were 5 or fewer months between diagnoses, only the pre-COPD episode of depression counted toward the incidence rate calculation. We defined the depression index date as the date the beneficiary met criteria for depression during the study period.

Covariates

We obtained demographic characteristics from the CCW files. Baseline comorbidities at COPD diagnosis were determined using CMS' CCW 27 flagged comorbid conditions, including depression and asthma, also a common comorbidity.(Centers for Medicare and

Medicaid Services) These chronic conditions are identified based on the presence of ICD-9-CM codes on inpatient, skilled nursing facility (SNF), home health, or outpatient claims using algorithms defined by CMS. If the date of first diagnosis of a particular chronic condition was prior to the date of COPD diagnosis, the patient was considered to have that chronic condition at baseline. We also created a measure of comorbidity by summing the indicator variables for chronic conditions including Alzheimer's disease and related dementias, atrial fibrillation, chronic kidney disease, heart failure, diabetes, ischemic heart disease, osteoarthritis, stroke, and asthma. COPD was not included in the count. Our measure had a range of 0-9 and was dichotomized at the mean (mean=2.0).

We defined nursing home residence within the month by the presence of any skilled nursing facility claim on an inpatient stay, or by the presence of healthcare common procedure coding system (HCPCS) or Place of Service codes on a SNF claim during the month.

We assessed characteristics suggestive of COPD severity. These characteristics included supplemental oxygen use, COPD-related hospitalization (measured as monthly COPD hospital days), and monthly COPD-related emergency department (ED) visits (measured as a monthly value).(Qian *et al.*, 2014; Qian *et al.*, 2014; Simoni-Wastila *et al.*, 2012) We searched carrier and DME claims for the following preventive health services utilization measures: influenza vaccination, colorectal cancer screening, prostate cancer screening, and mammography and pap smears. An annual count of preventive health services utilization measures (including mammography or Papanicolaou test) was created as an indicator of healthy behavior. This variable had a range of 0-3 and, based on its distribution, was dichotomized at one or more.

Data Analysis

Distributions of variables were examined overall and by incident depression status. Comparisons were made between beneficiaries with and without depression using chi-square or Student's t tests as appropriate.

We calculated rates of new episodes of depression both pre- and post-COPD. We counted months of Medicare Parts A, B, and D coverage with no Part C coverage pre- and post-COPD diagnosis. If a beneficiary received a depression diagnosis during the pre-COPD period, s/he no longer contributed person time to our rate calculations for the pre-COPD period, but would contribute again post-COPD. We calculated annualized rates per 100 beneficiaries diagnosed with COPD by sex and age category and calculated 95% confidence intervals around the rates. We counted number of depression episodes pre- and post-COPD diagnosis and divided by total months of person time. To determine whether rates of depression post-COPD varied over the study period, we calculated monthly rates during the first year following COPD diagnosis.

To estimate the risk of depression associated with COPD diagnosis and evaluate other factors associated with depression, we used a discrete time approach with COPD diagnosis as a time-varying exposure.(Allison, 1995) Unlike traditional survival analysis, discrete time analysis permits the inclusion of time-varying exposures and covariates. (Allison, 1995) We modelled risk of depression per month using generalized linear models with a binomial

distribution and a complementary log-log link.(Allison, 1995) Time varying covariates such as supplemental oxygen use, COPD-related ED visits, COPD-related hospitalizations, and preventive health measures, were included in the model along with other potential confounders identified in bivariate analysis. Risk ratios and 95% confidence intervals are reported.

Due to our large sample size, statistical significance was defined *a priori* as $p<0.001$. All analyses were performed with SAS version 9.3 (Cary, NC). This study was approved by the Institutional Review Board of the University of Maryland, Baltimore.

Results

We identified 836,725 Medicare beneficiaries with at least one inpatient or outpatient claim containing COPD ICD-9-CM diagnoses codes during 2006-2012. Of these, 154,059 (18%) were excluded for history of respiratory cancer, tuberculosis, asbestosis, or sarcoidosis, 116,865 (14%) were diagnosed with COPD prior to the study period, and 440,453 (53%) did not meet our Medicare coverage criteria, leaving 125,348 (15% of sample) in our study cohort.

Average age at COPD diagnosis was 72.6 (standard deviation (sd) 13.1) years. (Table 1) The cohort was primarily white (83%) and female (65%), with a high prevalence of ischemic heart disease (53%), heart failure (37%), and diabetes (37%) at the time of COPD diagnosis. Overall prevalence of depression diagnosed at any time during the study period was 32%. Beneficiaries with depression were younger (71.8 years vs. 73.0 years, $p<0.001$), more likely to be female (73% vs. 61%, $p<0.001$) and were more likely to have a history of depression prior to the study period (37% vs. 11%, $p<0.001$) compared to those who did not develop depression (Table 1).

Prior to the COPD diagnosis, 19,634 (16%) beneficiaries had an episode of depression compared with 29,281 (23%) who developed depression post-COPD diagnosis. Contained within these categories were the 9,359 (7%) of individuals with depression episodes both pre- and post-COPD diagnosis and more than 5 months between diagnoses. For these beneficiaries, the median number of months between depression episodes pre- and post-COPD was 16 (inter-quartile range 0, 34). Annual incidence rates of depression per 100 Medicare beneficiaries increased from the pre-COPD diagnosis period (6.1; 95% confidence interval (CI) 6.0, 6.2) to post-COPD diagnosis (9.4; 95% CI 9.3, 9.5)(Table 2). Pre-COPD diagnosis, incidence rates of depression were higher in women (7.1; 95% CI 7.0, 7.2) than in men (4.3; 95% CI 4.2, 4.4). Similarly, post-COPD diagnosis incidence rates of depression were higher in women (10.9; 95% CI 10.8, 11.1) than in men (6.7; 95% CI 6.6, 6.9). Overall incidence rates of depression post-COPD diagnosis were highest among Medicare beneficiaries 85 and older at COPD diagnosis (12.9; 95% CI 12.5, 13.2) and lowest among those aged 65-74 (6.7; 95% CI 6.5, 6.8).

Incidence rates of depression per 100 beneficiaries spiked during the two months following COPD diagnosis and then leveled off at approximately 13/100 in women and 8.5/100 in men

by 4 months post-COPD diagnosis (Figure 1). These rates are double the pre-COPD diagnosis rates.(Table 2)

The discrete time regression model included terms for COPD diagnosis, age, sex, race, myocardial infarction, Alzheimer's disease and related dementias, chronic kidney disease, history of depression prior to the study period, diabetes, heart failure, hip fracture, stroke, > 1 comorbid condition, region, original reason for Medicare entitlement, low income subsidy, evidence of nursing home residence in the month, ≥1 preventive health measure, monthly supplemental oxygen use, ≥1 COPD-related emergency department visit in the month, and ≥1 COPD-related hospitalization in the month. COPD diagnosis was associated with increased risk of depression (risk ratio (RR) 1.76; 95% confidence interval (CI) 1.73, 1.79) (Table 3). Nursing home residence within the month strongly predicted incident depression (RR 3.30; 95% CI 3.21, 3.40). Other factors strongly associated with increased risk of depression included a history of depression prior to the study period (RR 2.67; 95% CI 2.61, 2.72), female sex (RR 1.49; 95% CI 1.45, 1.52), and Alzheimer's disease and related dementias (RR 1.46; 95% CI 1.42, 1.50). Greater severity of COPD, as measured by supplemental oxygen use (RR 1.49; 95% CI 1.43, 1.55), COPD-related emergency department visits (RR 1.55; 95% CI 1.38, 1.74), and COPD-related hospitalizations (RR 4.59; 95% CI 4.09, 5.15) was associated with increased risk of depression.

Discussion

In this nationally-representative study of Medicare beneficiaries recently diagnosed with COPD, 23% developed depression. Diagnosis of COPD was associated with increased risk of depression. Rates of depression spiked during the two months following COPD diagnosis before plateauing at approximately double the pre-COPD diagnosis rates. Increased severity of COPD was significantly associated with increased risk of depression.

Prevalence of depression reported here is consistent with some prior studies (range 22%-27%), yet estimates of the risk of depression associated with COPD diagnosis have varied.(Omachi *et al.*, 2009; van Mannen *et al.*, 2002; Schneider *et al.*, 2010) Omachi *et al* reported an increase of 3.6 in the odds of depression measured with the Geriatric Depression Scale among individuals aged 40-65 years diagnosed with COPD.(Omachi *et al.*, 2009) VanManen *et al* reported an increase of 2.5 in the risk of depression measured with the Centers for Epidemiologic Studies Depression Scale only among individuals with severe COPD.(van Mannen *et al.*, 2002) These cross-sectional studies reported odds of depressive symptoms, rather than diagnosed depression which may explain the greater estimates. A large study conducted in the United Kingdom (UK) reported an annual rate of 16.2 cases of newly diagnosed depression per 1,000 individuals recently diagnosed with COPD, and adjusted odds of new diagnosed depression of 2.0 only among individuals with severe COPD.(Schneider *et al.*, 2010) Although the increase in risk is similar, our reported annualized rate (9.4/100 individuals) is nearly ten times greater. This is likely due to our emphasis on new episodes of depression rather than the first-ever diagnosis of depression and the strict exclusion criteria of the UK study. (Schneider *et al.*, 2010) The UK study excluded individuals with prior depression, alcohol or drug dependency, and those without three years of observation prior to diagnosis of COPD.(Schneider *et al.*, 2010)

Rates of depression spiked during the two months following COPD diagnosis. This time-frame corresponds with the first follow-up visit post-COPD diagnosis and suggests that the morbidity burdens of COPD may be especially acute in the early weeks of diagnosis before COPD symptoms have been adequately managed with appropriate therapy.(Global Strategy for the Diagnosis, Management and Prevention of COPD, 2015) Pulmonary rehabilitation improves emotional functioning as well as dyspnea and fatigue. (McCarthy *et al.*, 2015) Clinical guidelines could be updated to explicitly identify the benefit of pulmonary rehabilitation for the treatment of psychological symptoms associated with COPD, especially those experienced early upon diagnosis of COPD.(Qaseem *et al.*, 2011)

Consistent with prior studies, measures of COPD-severity were associated with increased risk of depression.(van Mannen *et al.*, 2002; Schneider *et al.*, 2010) As severity of COPD increases, exertional dyspnea results in limitation of activities and subsequent functional decline which may lead to an increase in depressive symptoms (Reardon *et al.*, 2006). Other reported associations between sex, disability, nursing home residence, and socioeconomic status and increased risk of depression are consistent with the literature.(Maurer *et al.*, 2008; Thakur and Blazer, 2008; Kessler *et al.*, 2003; Hasin *et al.*, 2005; Beekman *et al.*, 1997; Fiske *et al.*, 2009; Blazer *et al.*, 1991)

Prior history of depression increases the risk of a new episode of depression, which is not surprising because depression can be a chronic and relapsing disorder.(Keller *et al.*, 1992; American Psychiatric Association, 2013; Solomon *et al.*, 1997) Treatment of depression results in reduced healthcare costs, improved outcomes, and decreased mortality among younger COPD patients.(Qian *et al.*, 2013; Katon *et al.*, 2005; Unutzer *et al.*, 2002) Individuals with a past history of depression present an especially appropriate target for depression monitoring and treatment.(Jennings *et al.*, 2009; Fan *et al.*, 2007; Qian *et al.*, 2014) These efforts may lead to increased maintenance medication adherence and decreased COPD exacerbations among depressed individuals.(Qian *et al.*, 2014; Qian *et al.*, 2014)

This study is limited by its dependence on administrative claims data for diagnosis of COPD and depression. Clinical measures of COPD severity such as forced expiratory volume were not available. We constructed other measures of COPD severity, such as supplemental oxygen use and COPD-related hospital and emergency department visits which are commonly used in analyses of administrative claims data, yet these measures likely served only to differentiate individuals with severe illness from everyone else. (Qian *et al.*, 2014; Qian *et al.*, 2014; Simoni-Wastila *et al.*, 2012) Similarly, administrative data lack accurate measures of depression severity, such as the HAM-D scale.(Hamilton, 1960) Nonetheless, our results on the association between COPD severity and depression are consistent with prior reports.(Omachi *et al.*, 2009; van Mannen *et al.*, 2002; Schneider *et al.*, 2010) Our study population comprised only individuals who were diagnosed with COPD during the study period; hence our estimate of the risk of depression should be interpreted accordingly. We required more than five months between diagnoses of depression in order to isolate new episodes of the disorder, however it is possible that these were not new episodes of depression, which would have biased our results away from the null. Nonetheless, the median time between depression episodes for these beneficiaries was 16 months, suggesting these were new episodes of depression.

Conclusion

Diagnosis of COPD increases the risk of depression. The first few months after COPD diagnosis may be a particularly vulnerable time for new episodes of depression to develop, especially in persons with multiple risk factors for depression. Depression may decrease COPD medication adherence, health outcomes, and quality of life. This study will aid in the allocation of resources to monitor and provide support for individuals with COPD who are at a high risk of developing depression.

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JSA takes responsibility for the content of the manuscript, including the data and analysis. LSW made substantial contributions to conception and design, obtained funding, obtained data, contributed to data interpretation, article revision, final approval, and is accountable for all aspects of the work. TYH, YP, BK, SWL, PL made substantial contributions to data analysis and interpretation, article revision, final approval, and are accountable for all aspects of the work. GN and IH made substantial contributions to conception and design, data interpretation, article revision, final approval, and are accountable for all aspects of the work.

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Key Points

- This study aimed to estimate the rate of new episodes of depression and identify factors associated with depression among Medicare beneficiaries newly diagnosed with COPD.
- Diagnosis of COPD was associated with increased risk of depression.
- Rates of depression spiked during the two months following COPD diagnosis.
- Increased severity of COPD was significantly associated with increased risk of depression.
- This study will aid in the allocation of resources to monitor and provide support for individuals with COPD who are at a high risk of developing depression.

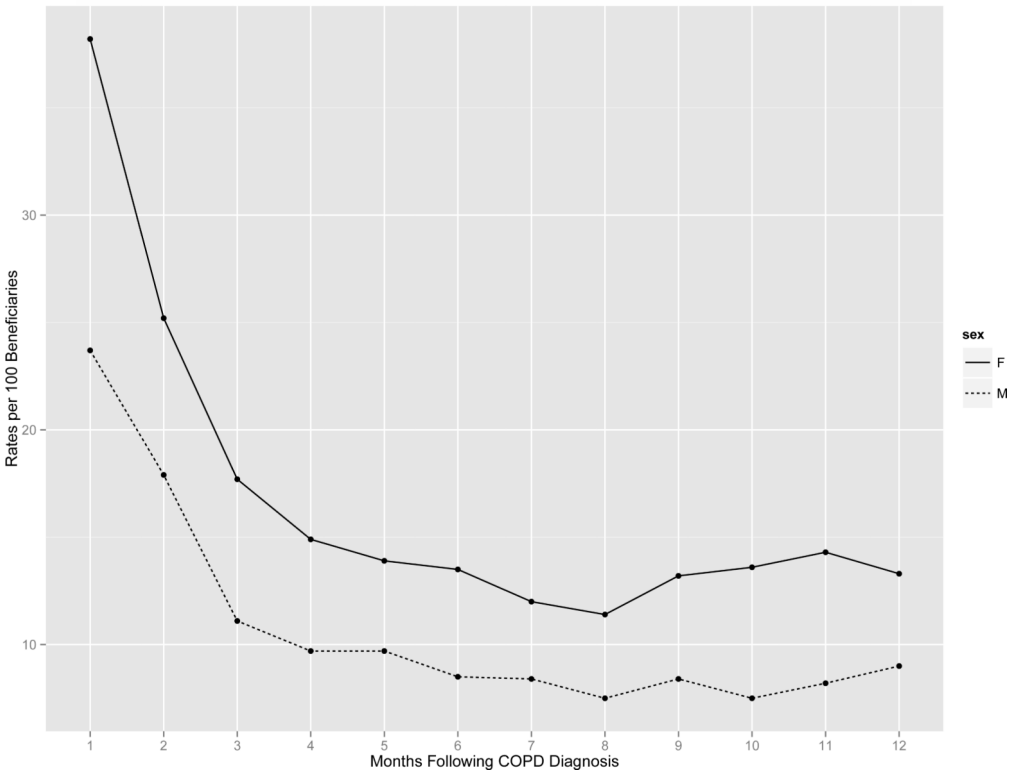

Figure 1.
Monthly Rates of Depression among Medicare Beneficaries Following COPD Diagnosis

Table 1

Baseline Characteristics of Medicare Beneficiaries Diagnosed with Chronic Obstructive Pulmonary Disease (COPD) Between 2006 to 2012 by Incident Depression Status, n=125,348

	Total Sample N=125,348	Depression N=39,554	No depression N=85,794	p-value[a]
Age, mean (standard deviation)	72.6 (13.1)	71.8 (14.2)	73.0 (12.5)	<0.001
Age categories, n(%)				<0.001
< 65	25,025 (20)	10,287 (26)	14,738 (17)	
65-74	41,901 (33)	10,679 (27)	31,222 (36)	
75-84	34,390 (27)	10,500 (27)	23,890 (28)	
> 84	24,032 (19)	8,088 (20)	15,944 (19)	
Female sex, n(%)	81,179 (65)	28,976 (73)	52,203 (61)	<0.001
Race/Ethnicity	<0.001			
White	104,133 (83)	33,622 (85)	70,511 (82)	
Black	13,129 (11)	3,644 (9)	9,485 (11)	
Hispanic	3,535 (3)	1,268 (3)	2,267 (3)	
Other	4,551 (4)	1,020 (3)	3,531 (4)	
COPD index year, n(%)				<0.001
2006	21,328 (17)	6,779 (17)	14,549 (17)	
2007	19,843 (16)	6,466 (16)	13,377 (16)	
2008	19,217 (15)	6,132 (16)	13,085 (15)	
2009	17,621 (14)	5,704 (14)	11,917 (14)	
2010	16,436 (13)	5,268 (13)	11,168 (13)	
2011	16,255 (13)	5,027 (13)	11,228 (13)	
2012	14,648 (12)	4,178 (11)	10,470 (12)	
Comorbid conditions, n(%)				
Acute myocardial infarction	6,791 (5)	2,360 (6)	4,431 (5)	<0.001
Alzheimer's disease	21,167 (17)	9,815 (25)	11,352 (13)	<0.001
Asthma	24,415 (20)	8,072 (20)	16,343 (19)	<0.001
Atrial fibrillation	20,570 (16)	6,785 (17)	13,785 (16)	<0.001
Cancer	14,463 (12)	4,538 (12)	9,925 (12)	0.62
Chronic kidney disease	29,018 (23)	10,465 (27)	18,553 (22)	<0.001
History of depression pre-2006	24,161 (19)	14,811 (37)	9,350 (11)	<0.001
Diabetes	46,286 (37)	16,084 (41)	30,202 (35)	<0.001
Heart failure	46,062 (37)	16,416 (42)	29,646 (35)	<0.001
Hip/pelvic fracture	5,848 (5)	2,582 (7)	3,266 (4)	<0.001
Ischemic heart disease	66,299 (53)	22,334 (57)	43,965 (51)	<0.001
Osteoporosis	26,786 (21)	10,007 (25)	16,779 (20)	<0.001
Rheumatoid arthritis / osteoarthritis	65,609 (52)	23,863 (60)	41,746 (49)	<0.001
Stroke / transient ischemic attack	22,045 (18)	8,860 (22)	13,185 (15)	<0.001
> 1 comorbid conditions[b], n(%)	77,546 (62)	26,910 (68)	50,636 (59)	<0.001

	Total Sample N=125,348	Depression N=39,554	No depression N=85,794	p-value[a]
Region				<0.001
Northeast	21,204 (17)	6,786 (17)	14,418 (17)	
Midwest	31,426 (25)	10,371 (26)	21,055 (25)	
South	53,495 (43)	16,991 (43)	36,504 (43)	
West	19,012 (15)	5,358 (14)	13,654 (16)	
Original reason for Medicare entitlement, n(%)				<0.001
Age	90,072 (72)	25,535 (65)	64,537 (75)	
Disability	33,408 (26)	13,343 (34)	20,065 (23)	
ESRD[c]	1,868 (1.5)	676 (2)	1,192 (1)	
Low income subsidy, n(%)	60,328 (48)	22,132 (56)	38,196 (45)	<0.001
Nursing home residence, n(%)	12,144 (10)	5,471 (14)	6,673 (8)	<0.001
≥1 Preventive health measure[d], n(%)	10,651 (9)	2,808 (7)	7,843 (9)	<0.001
COPD severity measures, n(%)				
Oxygen use in month of diagnosis	5,711 (5)	1,965 (5)	3,746 (4)	<0.001
≥1 COPD-related ED[e] visit	6,412 (5)	2,152 (5)	4,260 (5)	<0.001
≥1 COPD-related hospitalization	3,979 (3)	1,411 (4)	2,568 (3)	<0.001

[a] p-value from Chi-square goodness of fit test or Student's T-test as appropriate;

[b] Comorbid conditions included in count were: Alzheimer's disease, atrial fibrillation, chronic kidney disease, heart failure, diabetes, ischemic heart disease, osteoarthritis, stroke, and asthma;

[c] End-stage renal disease;

[c] Included influenza vaccination, colorectal cancer screening, prostate cancer screening (men), and mammography or pap smears (women);

[e] Emergency department

Table 2

Baseline Characteristics of Medicare Beneficiaries Diagnosed with Chronic Obstructive Pulmonary Disease (COPD) Between 2006 to 2012 by Incident Depression Status, n=125,348

	Age	Overall	Women	Men
Pre-COPD	<65	10.1 (9.8, 10.3)	12.7 (12.3, 13.2)	7.3 (6.9, 7.6)
	65-74	4.8 (4.7, 4.9)	6.0 (5.8, 6.2)	3.1 (2.9, 3.3)
	75-84	5.2 (5.0, 5.3)	6.0 (5.8, 6.2)	3.5 (3.3, 3.7)
	>84	6.2 (6.0, 6.4)	6.8 (6.6, 7.0)	4.1 (3.8, 4.4)
	Average	6.1 (6.0, 6.2)	7.1 (7.0, 7.2)	4.3 (4.2, 4.4)
Post-COPD	<65	12.4 (12.1, 12.7)	15.5 (15.1, 16.0)	9.1 (8.8, 9.5)
	65-74	6.7 (6.5, 6.8)	8.1 (7.9, 8.3)	4.7 (4.5, 4.9)
	75-84	9.2 (9.0, 9.4)	10.1 (9.9, 10.4)	6.9 (6.6, 7.2)
	>84	12.9 (12.5, 13.2)	13.8 (13.4, 14.2)	9.3 (8.7, 9.9)
	Average	9.4 (9.3, 9.5)	10.9 (10.8, 11.1)	6.7 (6.6, 6.9)

Table 3

Factors Associated with Risk of Depression Among Medicare Beneficiaries Diagnosed with Chronic Obstructive Pulmonary Disorder (COPD) During 2006-2012, n= 125,348

	Adjusted Relative Risk[a] (95% Confidence Interval)
COPD diagnosis	1.76 (1.73, 1.79)
Age at COPD diagnosis	0.98 (0.98, 0.99)
Sex	
Male	Reference
Female	1.49 (1.45, 1.52)
Race/Ethnicity	
White	Reference
Black	0.67 (0.65, 0.70)
Hispanic	0.57 (0.52, 0.63)
Other	0.97 (0.91, 0.99)
Comorbid conditions	
Acute myocardial infarction	1.01 (0.98, 1.06)
Alzheimer's disease	1.46 (1.42, 1.50)
Chronic kidney disease	1.15 (1.02, 1.17)
History of depression pre-COPD diagnosis[b]	2.67 (2.61, 2.72)
Diabetes	1.00 (0.99, 1.04)
Heart failure	1.06 (1.03, 1.08)
Ischemic heart disease	1.02 (1.00, 1.05)
Stroke / transient ischemic attack	1.13 (1.11, 1.16)
> 1 comorbid condition[c]	1.10 (1.07, 1.14)
Region	
Midwest	Reference
Northeast	0.92 (0.89, 0.94)
South	0.93 (0.91, 0.95)
West	0.87 (0.85, 0.90)
Outside the United States	0.84 (0.65, 1.08)
Original reason for Medicare entitlement	
Age	Reference
Disability	1.22 (1.19, 1.24)
ESRD[d]	1.21 (1.12, 1.30)
Low income subsidy	1.16 (1.14, 1.19)
Nursing home residence in month	3.30 (3.21, 3.40)
≥1 Preventive health measure[e]	0.93 (0.89, 0.96)
COPD severity measures	
Monthly supplemental oxygen	1.49 (1.43, 1.55)
≥1 COPD-related ED[f] visit in month	1.55 (1.38, 1.74)

	Adjusted Relative Risk[a] (95% Confidence Interval)
≥1 COPD-related hospitalization in month	4.59 (4.09, 5.15)

[a] Model adjusted for all variables shown in table;

[b] History of depression prior to the study period using ICD-9 codes (296.2x, 296.3x, 311.xx, 296.5x, 296.6x, 296.89, 298.0, 300.4, 309.2);

[c] Comorbid conditions included in count were: Alzheimer's disease, atrial fibrillation, chronic kidney disease, heart failure, diabetes, ischemic heart disease, osteoarthritis, stroke, and asthma;

[d] End-stage renal disease;

[e] Included influenza vaccination, colorectal cancer screening, prostate cancer screening (men), and mammography or pap smears (women);

[e] Emergency department