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Temporal Trends in Hospitalization Rates for Older Adults with Chronic Obstructive Pulmonary Disease

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Abstract

BACKGROUND—Over the last 15 years, substantial advances have been made in the treatment of chronic obstructive pulmonary disease (COPD). Little information is available, however, on whether these treatments have resulted in reduced rates of hospitalization and acute exacerbations among COPD patients. This retrospective cohort study examined changes in hospitalization rates among Medicare beneficiaries with COPD from 1999 to 2008.

METHODS—We analyzed data from 424,418 fee-for-service Medicare beneficiaries enrolled between 1999 and 2008 who were diagnosed with COPD. We examined temporal changes in the frequency of hospitalization and acute exacerbations among Medicare beneficiaries with COPD.

RESULTS—Over the 10-year study period, the hospitalization rates for COPD patients—adjusted for age, sex, race, socioeconomic status, region, and number of comorbidities—decreased: from 131 to 107 per 100 person-years for all causes ($P < .001$); from 58 to 44 per 100 person-years for all respiratory causes ($P < .001$); and from 73 to 63 per 100 person-years for nonrespiratory causes ($P < .001$). There was no change in prevalence of COPD in the Medicare population over this time. Additionally, the percentage of COPD patients hospitalized with 2 or more acute exacerbations decreased from 5.5% to 4.3% over the 10-year study period ($P < .001$).

CONCLUSION—Between 1999 and 2008, hospitalization rates decreased substantially among Medicare beneficiaries diagnosed with COPD.

Keywords

COPD; Hospitalization; Older adults

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Chronic obstructive pulmonary disease (COPD) is the third leading cause of death in the US,¹⁻³ accounts for one fifth of all hospitalizations in individuals over 75 years of age, and is the third most common cause of early readmission among individuals older than 65 years.^{4,5} The prevalence of COPD increases with age.⁶⁻⁸ Older adults are at particularly high risk for developing COPD due to aging-associated changes in physiology and immune function.^{4,6} For every 10-year increase in age, the prevalence of COPD increases 2-fold.^{4,6} COPD morbidity and mortality vary substantially by region and sociodemographic factors.^{2,9,10} Patients with COPD experience a high degree of comorbid illness and are at particularly high risk for cardiovascular disease, including hypertension, heart failure, and coronary artery disease.¹¹⁻¹⁵

Exacerbations of COPD, defined as an acute worsening of respiratory symptoms,¹⁶ are a major cause of mortality, morbidity, and reduced quality of life among COPD patients. Exacerbations are the most common cause of COPD hospitalization, accounting for more than 600,000 hospitalizations in the US annually, and direct costs of more than \$20 billion.¹⁷ In view of this, reduction of exacerbations is a major treatment goal in COPD management.¹⁶

Over the last 15 years, numerous advances have been made in the pharmacologic treatment and overall management of COPD.¹⁸⁻²¹ These include the introduction of revised COPD treatment guidelines in 2001, 2006, and 2011, combined long-term beta agonist and inhaled corticosteroid therapy in 2004, and long-term anti-cholinergic therapy in 2008.²² Although randomized trials have demonstrated the efficacy of these regimens in controlled settings with restricted samples,^{19,21} it is unknown whether these advances have resulted in improved outcomes in real-world settings. The purpose of our study, therefore, was to examine changes in hospitalization rates in patients with COPD as well as changes in the percentage of patients who experienced 2 or more acute exacerbations requiring hospitalization among Medicare beneficiaries with COPD from 1999 to 2008.

METHODS

Data Source

We conducted a retrospective cohort study using enrollment and claims data for a 5% national sample of Medicare beneficiaries.²³ The Centers for Medicare & Medicaid Services selected these beneficiaries based on the eighth and ninth digits (05, 20, 45, 70, 95) of their health insurance claim number. Data files were constructed to include patients' demographic and enrollment information (denominator file) and claims for hospital stays (MEDPAR file) and physician services (carrier claims file).²³ This study protocol was approved by the Institutional Review Board of the University of Texas Medical Branch.

A separate denominator file of patients with COPD was created for each calendar year (1999–2008). Each file was composed of patients 66 years or older in the year of interest who, in the previous year: were enrolled in Medicare parts A and B for the entire year; were not enrolled in a health maintenance organization; and had one of the following: 1) 2 outpatient visits, with different dates of service, with a COPD diagnosis;²⁴ 2) one acute care hospitalization with a COPD diagnosis based on International Classification of Diseases Ninth Revision, Clinical Modification (ICD-9-CM) codes (491.x [chronic bronchitis], 492.x [emphysema], or 496 [chronic airway obstruction]) listed in primary position as a discharge diagnosis; or 3) one acute care hospitalization with respiratory failure (518.81, 518.82, 518.84) listed in the primary position as a discharge diagnosis and COPD listed as the secondary diagnosis.

Risk Factors

Race/ethnicity was self-reported during the patient's initial enrollment with the Social Security Administration.²⁵ Socioeconomic status was based on whether the patient was eligible for state buy-in coverage provided by the Medicaid program for at least one month during the calendar year under study. Comorbidity was assessed using the Elixhauser comorbidity index.^{26,27}

Outcomes

The following categories of hospitalization were classified according to the primary ICD-9 codes listed on the discharge diagnosis: *all causes* (all ICD-9 codes); *all respiratory causes* (460.xx-519.xx); and *nonrespiratory causes* (all ICD-9 codes excluding all respiratory cause codes).

Because acute exacerbation represents one of the most critical and costly outcomes in COPD patients, we examined hospitalizations for this end point. A recent validation study reported that use of ICD-9-CM 491.21 yielded a substantially higher positive predictive value (97%) to identify hospitalizations for acute exacerbations of COPD compared with other ICD-9-CM based algorithms.²⁸ Based on this finding, we defined acute exacerbations as those listing ICD-9-CM 491.21 in the primary discharge diagnosis position.

Statistical Analysis

We calculated hospitalization rates separately for each year (1999–2008) by dividing the number of hospitalizations by all Medicare fee-for-service beneficiaries with COPD during each study year. Some beneficiaries were in a fee-for-service program for the entire year while others withdrew after a few months, or died before the end of the year. We therefore used the total beneficiary months at risk for each year as the denominator and the total number of hospitalizations for a given year as the numerator. All hospitalizations of interest were included in each analysis; a patient could contribute multiple hospitalizations in a single calendar year. We also examined the proportion of COPD patients who had 1, 2, or 3 acute exacerbations requiring hospitalization for each calendar year under study.

We conducted sensitivity analyses by running each of the above analyses using a 5-year look-back period. That is, for each calendar year of study, we included all patients 70 years or older who met the aforementioned criteria in one of the 5 years before hospitalization. This analysis increased the diagnostic window for COPD, allowing us to capture a more complete cohort of Medicare beneficiaries with COPD. The rates of hospitalization and acute exacerbations were comparable to those of the previously described cohort.

To evaluate the statistical significance of changes across years in patient characteristics, we used the Cochran-Armitage test of linear association for categorical variables. To assess variation in patient age over the calendar year, we used one-way analysis of variance. To assess temporal trends in rates of hospitalization (all cause, all respiratory, all non-respiratory) while adjusting for clustering within patients and multiple covariates (age, sex, race/ethnicity, socioeconomic status, region, and comorbidity), we used a generalized estimating equation model with repeated measurements assuming a Poisson distribution and accounting for the differences in follow-up time across calendar year. For all 3 outcomes, linear contrast was tested in the model.

Risk-adjusted hospitalization rates were calculated for each year that represented what the rate would have been if the mix of patients were identical over the study periods and using dummy indicator variables for each year in reference to the initial year (1999) from the multivariable models. The coefficients of these dummy indicator variables in the Poisson

regression model for each hospitalization rate represented changes for a given year compared with 1999. Finally, we tested a priori hypotheses of the interaction effect between patient characteristics (age, race, sex, and number of comorbidities) and calendar year on all respiratory cause hospitalization rates. All analyses were performed using SAS version 9.2 (SAS Institute Inc., Cary, NC).

RESULTS

Patient characteristics of the COPD cohorts by selected calendar years are reported in Table 1. Over the 10-year study period, there were a total of 192,295 unique patients and the annual cohort size ranged from 39,638 to 44,831. The mean age increased from 76.0 years to 76.5 years ($P < .0001$ for trend) over the study period. There was no substantial change in the proportion of female patients (52.4% to 53.1%) or in the proportion of black patients (5.4% to 5.3%) over time. The proportion of patients with 3 comorbid conditions increased from 28.7% in 1999 to 43.6% in 2008 ($P < .0001$). There was no substantial change in the distribution of patients across regions of the US over the study period.

Hospitalizations

Figure 1 shows that, over the 10-year study period, the hospitalization rates for COPD patients—adjusted for age, sex, race, socioeconomic status, region, and number of comorbidities—decreased, per 100 person-years, from: 131 to 107 ($P < .001$) for all causes; from 58 to 44 ($P < .001$) for all respiratory causes; and from 73 to 63 ($P < .001$) for all nonrespiratory causes.

Consistent with the above findings, Table 2 shows that, over the 10-year study period, the risk of hospitalization for COPD patients, adjusted for age, sex, race, region, socioeconomic status, and number of comorbidities decreased (relative to the reference year, 1999): from 1.00 in 1999 to 0.82 (95% confidence interval [CI], 0.81–0.84) for all causes; to 0.77 (95% CI, 0.75–0.80) for all respiratory causes; and to 0.86 (95% CI, 0.84–0.89) for all nonrespiratory disease. There was an interaction effect between calendar year and patient characteristics (sex, comorbidity) on hospitalizations for all respiratory causes. For example, the risk of COPD hospitalization in 2008 (vs 1998) in males was 0.73 (95% CI, 0.70–0.77), compared with 0.81 (95% CI, 0.77–0.84) in females. Also, for patients with 3 or more comorbidities, the risk of hospitalization for all respiratory causes in 2008 (vs 1998) was 0.83 (95% CI, 0.79–0.87), compared with 0.73 (95% CI, 0.79–0.87) in those with one or no comorbidities. No significant interaction was observed between calendar year and age or race. Finally, Figure 2 shows that, among all patients with COPD, the percentage hospitalized with 2 or more acute exacerbations decreased from 5.6% to 4.3% over the 10-year study period ($P < .001$). Likewise, the percentage of those hospitalized with 3 or more acute exacerbations decreased from 2.6% to 2.0% over the 10-year study period ($P < .001$). Finally, we repeated each of the above analyses using COPD cohorts defined using a 5-year look-back period in order to more completely identify patients with COPD (see Methods). Each of these analyses yielded results comparable to those found using the original study cohorts.

DISCUSSION

In this large observational study, we found that, between 1999 and 2008, hospitalization rates decreased substantially among Medicare beneficiaries diagnosed with COPD. Specifically, over the 10-year follow-up period, among all COPD patients, the hospitalization rate decreased by 18% for all causes, by 24% percent for all respiratory causes, and by 14% for all nonrespiratory causes. Likewise, the number of patients who

experienced 2 or more acute COPD exacerbations decreased by 23% over the 10-year study period.

Our findings were consistent with those of a prior study based on medical records of a nationally representative inpatient sample that reported a decrease in COPD hospitalization from 1999 to 2005,²⁹ as well as a Massachusetts-based study that reported a decrease in COPD hospitalization between 1993 and 2005.³⁰ A number of factors may have contributed to the reduction in hospitalization for all respiratory causes among COPD patients. First, the use of longacting beta agonists with corticosteroids, which increased after the release of combination long-acting beta agonists and corticosteroids in 2000, and the release of Global Initiatives for Chronic Obstructive Lung Disease guidelines in 2001 may have helped reduce the rate of acute exacerbations of COPD.¹² Research indicates that the use of long-acting beta agonists and inhaled corticosteroids increased substantially over the study period. In their study of the US Medicaid system from 1991 to 2010, Chiu et al³¹ reported that the use of both of these agents increased substantially between 1999 and 2008. Second, an increase in the rate at which older adults in the US received influenza vaccinations over the last decade³² also may have contributed to reduced morbidity and hospitalization in this cohort. Our analyses show that the rate of hospitalizations for pneumonia among all COPD patients decreased from 18.1 per 100 person-years in 1999 to 12.03 per 100 person-years in 2008. The decrease in the adult smoking rate in the US—from 23.5% in 1999 to 19.3% in 2010—also may have helped reduce the rate of hospitalization during the study period.^{33,34} Finally, reductions in second-hand smoke and other environmental exposures,^{35,36} occupational exposures,^{37–41} and biomass fuel exposure⁴² may have further contributed to this lower hospitalization rate over time.

Additional factors may underlie the observed decrease in all-cause hospitalizations among COPD patients over the study period. Improved access to screening and other preventive health services may have improved the overall health of COPD patients. Improved management of comorbid conditions also may have lowered the rate of overall hospitalization of COPD patients. For example, the increased use of statins after the release of the updated National Cholesterol Education Program guidelines may have contributed to substantial reductions in morbidity in COPD patients.^{43,44}

The results of this study may have been influenced by several limitations. First, because the study was limited to patients aged 66 years and older who had Medicare Parts A and B coverage, our findings may not be relevant to younger patients or to individuals enrolled in Medicare health maintenance organizations. Second, it is possible that the decrease in hospitalizations over the study period was attributable, at least in part, to changes in coding practices over time. We were particularly concerned that over the study period there was an increased likelihood of coding acute respiratory failure as the primary diagnosis, a trend that could have reduced the prevalence of COPD over time. To address this possibility, we classified any patient with a primary diagnosis of “acute respiratory failure” and a secondary diagnosis of COPD as having COPD. It also is possible that, over time, individuals with mild COPD who once would not have been included were diagnosed with COPD, leading to lower hospitalization rates. Recent studies suggest that the use of highly sensitive new technologies have resulted in increased diagnosis of conditions in more benign or mild form.^{45,46} To address this concern, we examined the age-adjusted annual prevalence of COPD, overall and by sex, over time. Our analyses showed no statistically significant increase in COPD prevalence over the study period. This finding was consistent with Centers for Medicare and Medicaid Services reports of COPD prevalence based on 5% Medicare data with a 1- and 3-year look-back period.⁴⁷ We also examined changes in the use of long-term oxygen therapy (LTOT)—a marker for severe COPD—among COPD patients over the study period. We found that the percentage of COPD patients who received

consistent LTOT increased from 23.0% in 2000 to 32.3% in 2008. Finally, our analyses showed that patient age and number of comorbidities increased over the study period. However, neither of these findings refutes the possibility of early detection bias. The underlying prevalence of COPD actually may have decreased over time as a result of the decreased underlying prevalence of smoking. The increase in LTOT may reflect an increase in physician awareness and improved access to treatment. Additionally, the observed increase in comorbidities over time may represent a trend of increased physician awareness for recording coexisting conditions. Assuming this possibility, adjusting for baseline comorbidities could result in an apparent decrease in hospitalization rate over time as more hospitalizations are attributed to the severity of coexisting conditions.

Our findings of decreased hospitalization over time in COPD patients also may reflect a secular trend whereby complex patients who once may have required hospitalization are managed in outpatient settings. To examine this possibility, we assessed the overall hospitalization rate for all Medicare beneficiaries from 1999 through 2008. During this period, the adjusted relative risk of decrease in hospitalizations (in 2008 vs 1999) for all causes was 0.90 (95% CI, 0.89–0.91), a substantially lower decrease than we observed among our COPD cohort (relative risk 0.82; 95% CI, 0.81–0.84, all causes; relative risk 0.77; 95% CI, 0.75–0.80, all respiratory). Finally, research indicates that the use of ICD-9-CM codes to identify hospitalizations for acute exacerbations substantially underestimates the burden of hospitalization for COPD and may misclassify patients admitted for other conditions.²⁸ We examined only severe exacerbations leading to acute care hospitalizations. We did not examine emergency department visits or outpatient visits for COPD. In view of this restriction, we may have underestimated substantially the number of acute exacerbations that occurred in our study cohort.

In summary, our findings show that hospitalization among Medicare beneficiaries with COPD decreased over the 10-year study period. This decrease may be attributable, in part, to advances in pharmacologic treatment and overall management of COPD and attendant comorbid conditions. It will be important for future studies to examine the extent to which the temporal patterns observed in this study persist in other COPD populations, particularly younger patients. Future studies also should assess whether temporal changes in specific medication prescribing patterns or disease management strategies are correlated with improvements in COPD outcomes. Given the growing prevalence of COPD in the US and throughout the world, particularly among older adults, understanding the patterns of COPD-related health care and outcomes in this population may offer clinicians and public health planners important insights.

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CLINICAL SIGNIFICANCE

- Chronic obstructive pulmonary disease (COPD) is the third leading cause of death in the US and is particularly prevalent in older adults.
- Over the last 15 years, numerous advances have been made in the pharmacologic treatment and overall management of COPD.
- Little information is available on whether new treatments and guidelines have resulted in improved outcomes among COPD patients.
- Between 1999 and 2008, hospitalization rates decreased substantially among Medicare beneficiaries diagnosed with COPD.

Figure 1.

Number of all cause, all respiratory, and all non-respiratory hospitalizations per 100 person-years among patients with COPD, 1999–2008.

1. Patients with chronic obstructive pulmonary disease (COPD) are defined as: 1) 2 outpatient professional claims, with different dates of service, with a COPD diagnosis listed in any position; 2) one acute care hospitalization with a COPD diagnosis based on International Classification of Diseases, 9th Revision (ICD-9) code 491.x [chronic bronchitis], 492.x [emphysema], or 496 [chronic airway obstruction]) listed in primary position as a discharge diagnosis; or 3) one acute care hospitalization with respiratory failure (518.81, 518.82, 518.84) listed in the primary position as a discharge diagnosis and COPD listed as the secondary diagnosis.
2. For all 3 outcomes, linear contrast was tested in generalized estimating equation (GEE) model and yielded *P* values of $< .0001$.

Figure 2. Percent of chronic obstructive pulmonary disease (COPD) patients with 1, 2, or 3 or more hospitalizations for severe exacerbations of COPD, over time. Acute exacerbation of COPD is defined as International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) 491.21 in the primary discharge diagnosis position.

Table 1

Characteristics of Medicare Beneficiaries Diagnosed with Chronic Obstructive Pulmonary Disease (COPD)*
by Year, 1999–2008

	1999	2002	2005	2008
Total number of patients	39,898	41,670	44,831	42,268
Age (years)				
66–74	18,246 (45.7)	18,258 (43.8)	19,554 (43.6)	18,067 (42.7)
75–84	17,267 (43.3)	18,549 (44.5)	19,861 (44.3)	18,448 (43.6)
85	4385 (11)	4863 (11.7)	5416 (12.1)	5753 (13.6)
Sex				
Male	19,022 (47.7)	19,629 (47.1)	21,316 (47.5)	19,947 (47.2)
Female	20,876 (52.3)	22,041 (52.9)	23,515 (52.5)	22,321 (52.8)
Race				
White	36,439 (91.3)	37,911 (91)	40,572 (90.5)	38,360 (90.8)
Black	2137 (5.4)	2390 (5.7)	2611 (5.8)	2236 (5.3)
Other	1322 (3.3)	1369 (3.3)	1648 (3.7)	1672 (4)
Low socioeconomic status	7303 (18.3)	8110 (19.5)	9117 (20.3)	8397 (19.9)
Elixhauser comorbidity score				
0	10,433 (26.1)	9064 (21.8)	7803 (17.4)	6126 (14.5)
1	10,724 (26.9)	10,834 (26)	11,132 (24.8)	9344 (22.1)
2	7271 (18.2)	7943 (19.1)	8988 (20)	8381 (19.8)
3	11,470 (28.7)	13,829 (33.2)	16,908 (37.7)	18,417 (43.6)
Region				
New England	2174 (5.4)	2216 (5.3)	2577 (5.7)	2589 (6.1)
Middle Atlantic	6242 (15.6)	6346 (15.2)	6405 (14.3)	5948 (14.1)
East North Central	7207 (18.1)	7402 (17.8)	7961 (17.8)	7417 (17.5)
West North Central	2853 (7.2)	2988 (7.2)	3199 (7.1)	2978 (7)
South Atlantic	8634 (21.6)	9452 (22.7)	10,061 (22.4)	9555 (22.6)
East South Central	3239 (8.1)	3366 (8.1)	3543 (7.9)	3262 (7.7)
West South Central	4021 (10.1)	4173 (10)	4769 (10.6)	4472 (10.6)
Mountain	1882 (4.7)	1989 (4.8)	2287 (5.1)	2209 (5.2)
Pacific	3646 (9.1)	3738 (9)	4029 (9)	3838 (9.1)

Medicare beneficiaries diagnosed with COPD are defined as: 1) 2 outpatient professional claims, with different dates of service, with a COPD diagnosis listed in any position; 2) one acute care hospitalization with a COPD diagnosis based on ICD-9 code 491.x [chronic bronchitis], 492.x [emphysema], or 496 [chronic airway obstruction] listed in primary position as a discharge diagnosis; or 3) one acute care hospitalization with respiratory failure (518.81, 518.82, 518.84) listed in the primary position as a discharge diagnosis and COPD listed as the secondary diagnosis.

Table 2

Multivariable Analysis of Risk of Hospitalization for Chronic Obstructive Pulmonary Disease (COPD) Medicare Patients by Year and Hospitalization Cause, 1999–2008

	All Causes	All Respiratory	All Nonrespiratory
Year			
1999	Referent	Referent	Referent
2000	0.97 (0.96–0.99)	0.93 (0.91–0.95)	1.01 (0.99–1.04)
2001	0.98 (0.96–1.00)	0.93 (0.90–0.95)	1.02 (0.99–1.04)
2002	0.95 (0.93–0.97)	0.90 (0.87–0.93)	0.99 (0.97–1.02)
2003	0.93 (0.91–0.95)	0.88 (0.86–0.91)	0.97 (0.94–0.99)
2004	0.89 (0.88–0.91)	0.83 (0.80–0.85)	0.95 (0.92–0.97)
2005	0.89 (0.87–0.90)	0.84 (0.81–0.86)	0.92 (0.90–0.95)
2006	0.87 (0.86–0.89)	0.81 (0.76–0.84)	0.92 (0.90–0.95)
2007	0.82 (0.80–0.84)	0.74 (0.72–0.77)	0.88 (0.85–0.90)
2008	0.82 (0.81–0.84)	0.77 (0.75–0.80)	0.86 (0.84–0.89)
Age, years			
65–75	Referent	Referent	Referent
75–84	1.08 (1.07–1.10)	1.02 (1.00–1.04)	1.13 (1.11–1.15)
85	1.18 (1.16–1.20)	1.05 (1.02–1.08)	1.27 (1.25–1.30)
Sex			
Male	Referent	Referent	Referent
Female	0.97 (0.96–0.98)	0.96 (0.94–0.98)	0.97 (0.96–0.99)
Race			
White	Referent	Referent	Referent
Black	1.03 (1.01–1.06)	1.01 (0.97–1.06)	1.05 (1.02–1.08)
Other	0.83 (0.80–0.86)	0.83 (0.78–0.88)	0.83 (0.80–0.87)
Socioeconomic status			
High	Referent	Referent	Referent
Low	1.33 (1.32–1.35)	1.41 (1.38–1.45)	1.28 (1.26–1.30)
Comorbidity			
0	Referent	Referent	Referent
1	1.38 (1.35–1.40)	1.29 (1.25–1.32)	1.46 (1.43–1.49)
2	1.98 (1.94–2.01)	1.77 (1.73–1.82)	2.16 (2.12–2.21)
3	4.42 (4.35–4.49)	3.61 (3.52–3.70)	5.16 (5.06–5.27)
Region			
New England	Referent	Referent	Referent
East North central	1.09 (1.06–1.12)	0.94 (0.89–10.98)	1.10 (1.07–1.14)
East South central	1.18 (1.14–1.22)	1.07 (1.03–1.12)	1.15 (1.11–1.19)
West North central	1.07 (1.04–1.11)	1.05 (1.01–1.11)	1.09 (1.05–1.13)
West South central	1.11 (1.08–1.15)	0.94 (0.90–00.98)	1.13 (1.09–1.17)
Mid Atlantic	0.99 (0.96–1.02)	1.22 (1.16–1.29)	1.03 (0.99–1.06)
South Atlantic	0.98 (0.96–1.01)	1.09 (1.04–1.15)	1.02 (0.98–1.05)

	All Causes	All Respiratory	All Nonrespiratory
Mountain	0.89 (0.86–0.93)	0.84 (0.80–0.90)	0.93 (0.89–0.97)
Pacific	0.89 (0.86–0.91)	0.84(0.80–0.88)	0.92 (0.89–0.96)

Notes: The following categories of hospitalization were classified according to the primary International Classification of Diseases, 9th Revision (ICD-9) codes listed on the discharge diagnosis: all causes (all ICD-9 codes); all respiratory causes (460.xx-519.xx); and nonrespiratory causes (all ICD-9 codes excluding all respiratory cause codes).

Race/ethnicity was self-reported during the patient's initial enrollment with the Social Security Administration.²³

Socioeconomic status was based on whether the patient was eligible for state buy-in coverage provided by the Medicaid program for at least 1 month during the calendar year under study.

Comorbidity was assessed using the Elixhauser comorbidity index.