Participation in Pulmonary Rehabilitation after Hospitalization for Chronic Obstructive Pulmonary Disease among Medicare Beneficiaries

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Abstract

Rationale: Current guidelines recommend pulmonary rehabilitation (PR) after hospitalization for a chronic obstructive pulmonary disease (COPD) exacerbation, but little is known about its adoption or factors associated with participation.

Objectives: To evaluate receipt of PR after a hospitalization for COPD exacerbation among Medicare beneficiaries and identify individual- and hospital-level predictors of PR receipt and adherence.

Methods: We identified individuals hospitalized for COPD during 2012 and recorded receipt, timing, and number of PR visits. We used generalized estimating equation models to identify factors associated with initiation of PR within 6 months of discharge and examined factors associated with number of PR sessions completed.

Results: Of 223,832 individuals hospitalized for COPD, 4,225 (1.9%) received PR within 6 months of their index hospitalization, and 6,111 (2.7%) did so within 12 months. Median time from discharge until first PR session was 95 days (interquartile range, 44–190 d), and median number of sessions completed was 16 (interquartile range, 6–25). The strongest factor associated with initiating PR within 6 months was prior home oxygen use (odds ratio [OR], 1.49; 95% confidence interval [CI], 1.39–1.59). Individuals aged 75–84 years and those aged 85 years and older (respectively, OR, 0.70; 95% CI, 0.66–0.75; and OR, 0.25; 95% CI 0.22–0.28), those living over 10 miles from a PR facility (OR, 0.42; 95% CI, 0.39–0.46), and those with lower socioeconomic status (OR, 0.42; 95% CI, 0.38–0.46) were less likely to receive PR.

Conclusions: Two years after Medicare began providing coverage for PR, participation rates after hospitalization were extremely low. This highlights the need for strategies to increase participation.

Keywords: chronic obstructive pulmonary disease; Medicare; hospitalization; rehabilitation

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Chronic obstructive pulmonary disease (COPD) is the fourth leading cause of death in the United States. Roughly 16 million people have a diagnosis of COPD, and millions more are undiagnosed (1). The burden on the U.S. healthcare system is substantial: COPD is responsible for over 700,000 hospitalizations annually, and the total direct costs of COPD are estimated at $29.5 billion (2–4). Patients with COPD also face physical limitations that negatively impact their physical and mental health (5, 6).

Pulmonary rehabilitation (PR) is a treatment program for patients living with COPD. PR is a patient-tailored intervention that includes exercise training and self-management education aimed at sustained behavior change to improve physical and psychological well-being (7). Although the delivery of PR varies, PR typically takes place in a center-based setting, with individuals attending two or three sessions per week for a course of 8 weeks or more (8). PR has been shown to reduce dyspnea, reduce fatigue, increase exercise tolerance, and improve quality of life (9). There is also evidence that PR reduces hospital readmissions (10). Current guidelines recommend that patients begin PR within 3 weeks after a hospitalization for COPD (7, 11, 12).

Despite these benefits, studies in the United States and elsewhere suggest that PR is underused in the setting of stable COPD (13–15); however, rates of receipt of PR after hospitalization for a COPD exacerbation are unknown. Many individuals with COPD are never referred for PR; of those referred, a significant percentage do not make it to the first visit (16). Furthermore, of those who do attend, only a fraction complete the recommended number of sessions within 1 year (15, 17, 18). After Medicare's policy change in 2010, which provided coverage for PR services and effectively opened up PR to millions of U.S. Medicare beneficiaries, we sought to examine the use of PR by elderly patients after a hospitalization for COPD.

Methods

Cohort

From the Centers for Medicare and Medicaid Services, we obtained beneficiary denominator and standard analytic files for every individual hospitalized in an acute care hospital in 2012, with a principal diagnosis of COPD or a principal diagnosis of acute respiratory failure combined with a secondary diagnosis of COPD with acute exacerbation. We defined the cohort in accordance with methods used by the Centers for Medicare and Medicaid Services. *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9), diagnosis codes were used to define the cohort as follows: a principal diagnosis of COPD, ICD-9-CM code 490, 491.0, 491.1, 491.21, 491.22, 491.8, 491.9, 492.8, 493.20, 493.21, 493.22, or 496, or a principal diagnosis of acute respiratory failure or arrest, ICD-9-CM code 518.81, 518.82, 518.84, 786.09, or 799.1, when combined with a secondary diagnosis of COPD with acute exacerbation, ICD-9-CM code 491.21, 491.22, 493.21, or 493.22 (19).

We included individuals aged 66 years or older if they were continuously enrolled for 1 year in Medicare fee-for-service from their index admission and had not received PR during the prior year. We excluded individuals aged 65 years to ensure that all subjects in our cohort had at least one prior year of Medicare data to assess comorbidities and healthcare use. To limit the study to those individuals who would likely benefit from and be eligible to participate in PR, we excluded those who were hospitalized for more than 30 days at their index hospitalization; died within 30 days of their index hospitalization; were transferred to another acute care facility, hospice, long-term care facility, or court or law enforcement; and discharged against medical advice.

PR Services Use

To identify patients who received PR and providers of PR, we used healthcare common procedure coding system (HCPCS) codes (G0424 [COPD] and G0237, G0238, and G0239 [non-COPD]) from the Medicare outpatient file, which contains claims data from institutional outpatient providers (i.e., hospital outpatient-based facilities), and carrier files, which contain claims from noninstitutional providers (i.e., physicians' offices). We matched the denominator file with these claims files to identify individuals who received at least one PR session within 6 months and 1 year after discharge from their index hospitalization. The providers associated with these PR claims were identified as PR providers. As with other medical procedures, the incentive to bill for services should lead to a high level of validity of these claims data as a means of measuring PR services received by this population (20). We included HCPCS codes for PR regardless of whether it was specifically ordered for COPD to ensure that we ascertained all PR received by patients with COPD. We measured the number of days from the index hospitalization to the first PR session and the number of sessions attended.

Predictors of PR Use and Covariates

At the individual level, we included measures of age, sex, race and ethnicity, and Medicaid eligibility (a proxy for lower socioeconomic status [SES]) from the Medicare denominator file. To investigate the contribution of comorbidity burden to participation in PR, we captured ICD-9 codes from physician office visits, hospital outpatient visits, and hospitalizations in the year before the index hospitalization. We used these diagnoses to compute a longitudinal Charlson comorbidity index (20–23) and divided subjects into groups of low, medium, and high comorbidity burden based on the weighted index. As an additional marker of disease severity, we identified (from the Medicare durable medical equipment files) home oxygen use in the 90 days before hospitalization. We recorded treatment with noninvasive or invasive mechanical ventilation during the index hospitalization via ICD-9 procedure codes. In addition, using ICD-9 diagnoses, we determined whether the subject was a current smoker at the time of the index hospitalization.

We determined geographic accessibility of PR by calculating the distance from the 65-and-over population-weighted centroid of each individual's zip code of residence to the nearest PR provider (25). We extracted hospital characteristics such as the geographic region, rural or urban location, teaching status, and size of the hospital (based on the number of beds) from the Medicare provider of service files.

Statistical Analysis

We calculated individual and hospital characteristics as frequencies and percentages for categorical variables and mean with standard deviation or median with interquartile range (IQR) for continuous variables. Given the very large size of our study population, associations between receipt of PR within 6 months of index discharge and individual and hospital characteristics were assessed using absolute

standardized differences, where differences greater than 10% were considered meaningful (26, 27). To identify factors associated with receipt of PR within 6 months of index discharge, we developed a generalized estimating equation model with logit link accounting for the natural clustering of individuals within hospitals. This model included demographics; distance to the nearest PR facility; comorbidity burden; current smoking status; ventilator support during the index admission; hospital admissions and oxygen use in the year before the index hospitalization; and hospital size, region, teaching status, and rural or urban status.

We restricted our cohort to individuals who had at least one PR session within 1 year of index discharge and modeled factors associated with the number of PR sessions attended. After visually examining the distribution of the number of sessions, we categorized individuals into three clinically meaningful groups: those completing 1–11, 12–23, and greater than or equal to 24 sessions. We fit the three-level PR sessions variable as an ordinal outcome with individual characteristics, including demographics, comorbidity burden, smoking status, markers of disease severity, and distance to nearest PR provider, as independent variables.

All analyses were performed using SAS (version 9.4; SAS Institute) and STATA 15 (StataCorp) software. Provider service locations were geocoded using Texas A&M University GeoServices (28). The Institutional Review Board at Baystate Medical Center approved the study.

Results

Demographics

After exclusions, a total of 223,832 Medicare beneficiaries hospitalized for COPD in 2012 were included in our cohort (Figure 1). The median age was 77 years (IQR, 71–83 yr); the majority were female (59.4%) and white non-Hispanic (84.8%); and 27.9% were eligible for Medicaid. Half of the patients lived within 5.3 miles (IQR, 2.4–13.6 mi) of the nearest PR provider (Table 1).

Clinical Features and Outcomes

The majority of individuals (87.3%) had a principal diagnosis of COPD; 12.7% had a principal diagnosis of acute respiratory failure with a secondary diagnosis of COPD. The three most common comorbidities were congestive heart failure (61.2%), diabetes (49.4%), and peripheral vascular disease (48.9%). In addition, 20.8% of individuals were current smokers. The median weighted Charlson comorbidity index was 4 (IQR, 2–7). Nearly half (48.6%) of all subjects had been hospitalized during the prior year. More than one-third (35.3%) received home oxygen in the 90 days before hospitalization. During the index admission, 5.7% were treated with noninvasive ventilation, and 3.3% were treated with invasive mechanical ventilation (Table 1). The all-cause 1-year readmission rate was 63.2%, and the 1-year mortality rate was 14.4%.

Receipt of PR

Receipt of PR after a hospitalization was rare. Fewer than 2 in 100 potentially eligible individuals hospitalized for COPD (1.9%) received any PR within 6 months after a hospitalization ($n = 4,225$). Examining cumulative enrollment rates over time, we found that 732 (0.3%) patients had received PR within 1 month of discharge, 3,321 (1.5%) had received PR within 3 months, and 6,111 (2.7%) had

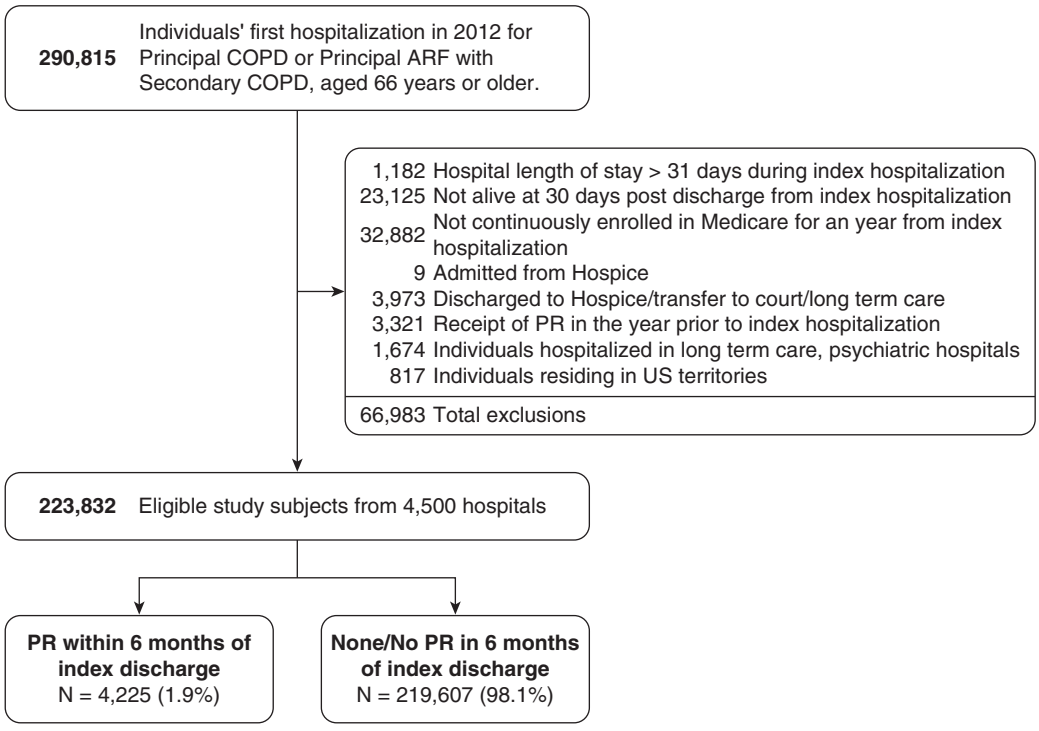

Figure 1. Flowchart showing study selection criteria. ARF = acute respiratory failure; COPD = chronic obstructive pulmonary disease; PR = pulmonary rehabilitation.

Table 1. Individual characteristics and associations with incidence of pulmonary rehabilitation

Individual Characteristic	Total (*N* [%])	None/Later Start of PR (*n* [%])	PR within 6 Mo of Discharge (*n* [%])	Absolute Standardized Differences (%)
Total	223,832 (100.0)	219,607 (98.1)	4,225 (1.9)	
Demographics				
Age, yr, median (IQR)	77.0 (71.0–83.0)	77.0 (71.0–83.0)	74.0 (70.0–79.0)	
Mean (SD), yr	77.4 (7.6)	77.4 (7.6)	74.8 (6.1)	38.0
Sex				
Male	90,824 (40.6)	88,875 (40.5)	1,949 (46.1)	11.4
Race/ethnicity				22.5
Non-Hispanic white	189,889 (84.8)	186,018 (84.7)	3,871 (91.6)	
Black (or African American)	18,850 (8.4)	18,624 (8.5)	226 (5.3)	
Hispanic	9,977 (4.5)	9,903 (4.5)	74 (1.8)	
Other	5,116 (2.3)	5,062 (2.3)	54 (1.3)	
Distance to nearest PR, mi, median (IQR)	5.3 (2.4–13.6)	5.4 (2.4–13.7)	3.7 (1.8–7.6)	
Mean (SD), mi	13.6 (89.2)	13.74 (89.9)	6.34 (37.3)	10.8
Dual eligibility (Medicaid buy-in)	62,500 (27.9)	61,985 (28.2)	515 (12.2)	40.8
Current tobacco smoker	46,580 (20.8)	45,719 (20.8)	861 (20.4)	1.1
Principal diagnosis				
COPD	195,505 (87.3)	191,866 (87.4)	3,639 (86.1)	3.6
ARF	28,327 (12.7)	27,741 (12.6)	586 (13.9)	
Charlson comorbidities				
Congestive heart failure	136,881 (61.2)	134,794 (61.4)	2,087 (49.4)	24.3
Diabetes without complications	110,631 (49.4)	108,953 (49.6)	1,678 (39.7)	20.0
Peripheral vascular disease	109,432 (48.9)	107,597 (49.0)	1,835 (43.4)	11.2
Cerebrovascular disease	87,253 (39.0)	85,930 (39.1)	1,323 (31.3)	16.4
Renal disease	77,495 (34.6)	76,373 (34.8)	1,122 (26.6)	17.9
Myocardial infarction	57,164 (25.5)	56,267 (25.6)	897 (21.2)	10.4
Cancer	51,832 (23.2)	50,728 (23.1)	1,104 (26.1)	7.0
Diabetes with complications	44,830 (20.0)	44,277 (20.2)	553 (13.1)	19.1
Dementia	29,453 (13.2)	29,309 (13.3)	144 (3.4)	36.5
Mild liver disease	23,940 (10.7)	23,480 (10.7)	460 (10.9)	0.6
Connective tissue disease/rheumatic disease	20,884 (9.3)	20,527 (9.3)	357 (8.4)	3.2
Peptic ulcer disease	14,462 (6.5)	14,253 (6.5)	209 (4.9)	6.7
Weighted Charlson comorbidity index				
Mean (SD)	4.6 (3.2)	4.6 (3.2)	3.8 (3.0)	27.0
Median (IQR)	4 (2–7)	4 (2–7)	3 (1–5)	
Prior hospitalization factors				
Prior-year admissions				22.4
No admits	115,068 (51.4)	112,504 (51.2)	2,564 (60.7)	
One admissions	52,024 (23.2)	51,118 (23.3)	906 (21.4)	
Two admissions	26,145 (11.7)	25,738 (11.7)	407 (9.6)	
Three or more admissions	30,595 (13.7)	30,247 (13.8)	348 (8.2)	
Home oxygen use				
In 90 d before index hospitalization	78,973 (35.3)	77,158 (35.1)	1,815 (43.0)	16.1
Index hospitalization factors				
Noninvasive ventilation	12,763 (5.7)	12,504 (5.7)	259 (6.1)	1.9
Invasive mechanical ventilation	7,272 (3.3)	7,133 (3.2)	139 (3.3)	0.2

Definition of abbreviations: ARF = acute respiratory failure; COPD = chronic obstructive pulmonary disease; IQR = interquartile range; PR = pulmonary rehabilitation; SD = standard deviation.

received PR within 12 months. The median number of days from the index hospitalization to the first instance of PR receipt was 95 days (IQR, 44–190 d). Individuals who received PR completed a median of 16 (IQR, 6–25) sessions over the course of 1 year (Figure 2).

Predictors of PR Receipt

Factors that were independently associated with PR receipt within 6 months included younger age, male sex, white race, and higher SES (Table 2). Compared with individuals aged 66–74 years, those aged 75–84 years were 30% percent less likely to receive PR, and those aged 85 years and older were 75% less likely to receive PR. Men were 21% more likely than women to receive at least one PR session. Compared with non-Hispanic white patients, African American patients were 31% less likely to receive PR, and Hispanic patients were 41% less likely to receive PR. Those who were dually eligible for Medicaid and Medicare, indicating lower SES, were 58% less likely to receive PR (Table 2).

Clinical factors, such as number of prior admissions and severity of comorbidity burden, were also important in predicting PR receipt. As the number of prior admissions increased, the probability of receiving PR declined. Compared with those with no prior admissions, individuals with one, two, or three or more admissions in the prior year

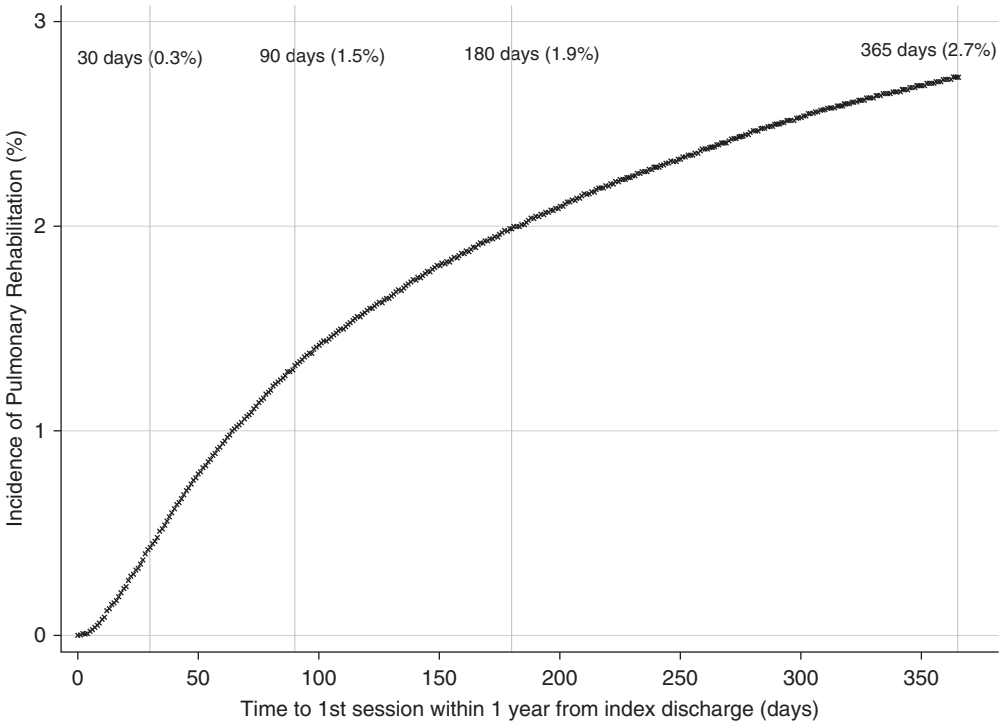

Figure 2. Participation in pulmonary rehabilitation in 1 year after index discharge.

were 16%, 22%, and 40% less likely to receive PR, respectively. Individuals with a weighted Charlson comorbidity index score of 6 or higher were 33% less likely to participate in PR than those with a weighted index of 0–2. In contrast, those receiving home oxygen within 90 days before their hospitalization were 49% more likely to participate in PR than those without. Notably, ventilatory support (noninvasive or invasive mechanical ventilation) during the index hospitalization had no association with PR receipt.

As we anticipated, those living in zip codes closer to PR providers were more likely to receive PR, with a clear threshold difference at around 10 miles of travel distance. Specifically, those living in zip codes within 5–10 miles of the nearest PR provider were only 11% less likely to receive PR than those within 5 miles of the nearest provider; however, those who were over 10 miles from the nearest PR provider were 58% less likely to receive PR. Individuals hospitalized in the northeastern, midwestern, and western regions of the United States were 18%, 58%, and 14%, respectively, more likely to receive PR than those in the South.

PR Adherence

Among those who received one or more sessions of PR within 1 year ($n = 6{,}111$), over half completed 16 sessions, and approximately 10% completed 35 sessions or more. We found that sex, SES (i.e., Medicaid eligibility), distance to the nearest provider, and clinical factors continued to be associated with the intensity of PR attendance. On average, women, those with lower SES, those more than 10 miles from the nearest provider, and current smokers completed fewer sessions. Patients who had more prior admissions and higher comorbidity burden also completed fewer sessions (Table 3).

Discussion

In this national study of elderly Medicare beneficiaries hospitalized for COPD, we found an enormous gap between the recommendations found in professional society guidelines and recent clinical practice (12). The vast majority of individuals who might benefit from PR never receive it: Less than 2% received PR within 6 months of their index hospitalization. Furthermore, although rates were low overall, we found evidence that receipt of PR was even lower among those in disadvantaged patient populations. Individuals who are female, nonwhite, and dually eligible for Medicaid and Medicare were less likely to receive PR after a hospitalization for COPD. Furthermore, among those who received any PR, those who were female or Medicaid eligible completed fewer PR sessions. At the zip code level, distance to PR facility was a factor, and living closer to a PR facility was associated with increased receipt of PR. Clinical factors helped explain PR receipt in predictable ways, with younger, healthier individuals more likely to receive PR. In addition, those with more prior hospital admissions were less likely to attend PR, suggesting that healthcare providers are missing an opportunity to improve the quality of life and potentially to reduce readmissions of patients who are most impacted by their disease. Moreover, these findings underscore the need to make sure that PR is made accessible to all patients who could potentially benefit, including those who face multiple challenges, whether health related, social, or financial. Recent guidelines recommend PR after hospitalization for patients

Table 2. Predictors of receipt of pulmonary rehabilitation

Factor	OR (*95% CI*)
Age group	
66–74 yr	Referent
75–84 yr	0.70 (0.66–0.75)
⩾85 yr	0.25 (0.22–0.28)
Distance to nearest PR group	
⩽5 mi	Referent
>5 and ⩽10 mi	0.89 (0.82–0.96)
>10 mi	0.42 (0.39–0.46)
Male sex	1.21 (1.14–1.29)
Race/ethnicity	
White	Referent
Black or African-American	0.69 (0.60–0.79)
Hispanic	0.59 (0.47–0.75)
Other	0.71 (0.54–0.93)
Dual eligibility (state Medicaid buy-in)	0.42 (0.38–0.46)
Tertiles of weighted Charlson comorbidity index score	
Min–max: 0–2	Referent
Min–max: 3–5	0.86 (0.80–0.92)
Min–max: 6–27	0.67 (0.61–0.73)
Prior admissions	
No prior admissions	Referent
One admission	0.84 (0.77–0.90)
Two admissions	0.78 (0.70–0.87)
Three or more admissions	0.60 (0.54–0.68)
Home oxygen use in 90 d before hospitalization	1.49 (1.40–1.59)
Noninvasive ventilation	1.02 (0.90–1.17)
Invasive mechanical ventilation	0.99 (0.83–1.18)
Current tobacco user	0.79 (0.73–0.86)
Hospital region	
Northeast	1.18 (1.05–1.33)
Midwest	1.58 (1.44–1.74)
South	Referent
West	1.14 (1.00–1.30)
Rural hospitals	1.03 (0.93–1.15)
Teaching hospitals	0.99 (0.90–1.09)
Hospital size	
<200 beds	Referent
201–400 beds	0.92 (0.83–1.03)
⩾401 beds	1.09 (0.96–1.23)

Definition of abbreviations: CI = confidence interval; OR = odds ratio; PR = pulmonary rehabilitation.

with COPD exacerbations; our findings illustrate just how much progress needs to be made to close the gap we have documented.

This study builds on prior work by Nishi and colleagues. They examined PR receipt among the 5% sample of Medicare beneficiaries with an inpatient or outpatient diagnosis of COPD, and they found that rates of PR attendance ranged from 2.6% in 2003 to 3.7% in 2012 (13). In contrast, in our study, we examined PR attendance during the period after hospitalization for COPD exacerbation. The differences in our overall rates of PR use are also explained by differences in our definition of PR receipt. Where Nishi and colleagues used both HCPCS and current procedural terminology codes, which can be overly broad (e.g., "therapeutic procedures, group"), we used HCPCS codes exclusively to accurately identify PR.

Studies in the United Kingdom have also found that there is much room for improvement in PR participation; however, rates are much higher than in the United States (29, 30). Hakamy and colleagues conducted a study in the United Kingdom using data from The Health Information Network primary care database and found that 9.8% of patients with COPD received PR (29). As in our study, older individuals and those with lower SES were less likely to receive PR and also less likely to adhere to PR. In contrast to our study, Hakamy and colleagues found that those with higher Charlson comorbidity index scores were more likely to receive PR; furthermore, they found no relationship between sex and PR receipt. They also included a measure of dyspnea and showed that worse dyspnea scores were associated with PR receipt. This finding, together with our finding that individuals receiving home oxygen are more likely to attend PR, suggests that increased dyspnea, either on its own or through increasing interaction with the healthcare system, may increase participation in PR. Individuals with increased dyspnea may be more willing to participate in PR, or they may be more likely to receive the necessary diagnostic tests and referrals. Furthermore, these findings suggest that low rates of PR are not unique to the United States and that differing rates of use by patient characteristics, such as sex, may be driven by systemic or cultural factors.

Our focus on the period after hospitalization is especially relevant, given the recent addition of COPD to the list of conditions used in Medicare's Hospital Readmissions Reduction Program. This change, together with the growth of accountable care organizations, and bundled forms of payment have focused attention on identifying and implementing programs to reduce the risk of readmissions and improve longer-term outcomes for patients with COPD and other chronic conditions. Although there are limitations in the current understanding of how to effectively prevent readmissions for COPD, beyond its many other benefits, PR is an intervention that has been identified as a promising strategy for preventing readmissions (10, 31). Our study shows that there is room for considerable growth in PR use and underscores the need to understand why PR use is so low.

In addition, further study is needed to disentangle the effects of geographic variation in PR programs from the role of race and SES in explaining lower rates of PR use among nonwhite individuals and those eligible for Medicaid. Prior studies have shown that COPD is more prevalent in rural areas of the United States, as are Medicare hospitalizations for COPD and deaths, but more research is needed to understand the distribution of PR programs and whether there are gaps in accessibility (32). This is especially important because distance to PR facilities was a strong negative predictor of PR receipt in this study, and other studies

Table 3. Ordinal regression showing factors predicting receipt of higher number of pulmonary rehabilitation sessions

Individual Factor	OR (*95% CI*)
Age group	
66–74 yr	Referent
75–84 yr	1.06 (0.96–1.17)
⩾85 yr	0.90 (0.75–1.09)
Distance to nearest PR program	
⩽5 mi	Referent
>5 and ⩽10 mi	1.03 (0.91–1.15)
>10 mi	0.81 (0.71–0.93)
Male sex	1.24 (1.13–1.37)
Race/ethnicity	
White	Referent
Black or African American	0.98 (0.80–1.21)
Hispanic	0.70 (0.48–1.01)
Other	0.75 (0.49–1.15)
Dual eligibility (state Medicaid buy-in)	0.48 (0.41–0.56)
Home oxygen use in 90 d before hospitalization	0.93 (0.85–1.03)
Current tobacco user	0.86 (0.76–0.97)
Prior admissions	
No prior admissions	Referent
One admission	0.80 (0.71–0.90)
Two admissions	0.77 (0.65–0.91)
Three or more admissions	0.62 (0.51–0.75)
Tertiles of weighted Charlson comorbidity index score	
Min–max: 0–2	Referent
Min–max: 3–5	0.84 (0.75–0.93)
Min–max: 6–27	0.72 (0.63–0.82)

Definition of abbreviations: CI = confidence interval; OR = odds ratio; PR = pulmonary rehabilitation.

have shown that distance to PR facilities was negatively associated with adherence to PR (33). In addition, research outside the United States has shown that patients living in disadvantaged areas are less likely to complete PR, even though the benefits of PR are consistent across populations in different areas (34). Nonclinical factors, such as spatial accessibility and the nature of PR programs, may play a role in creating barriers to enrollment and adherence. Our study suggests that more needs to be done to identify and address these barriers, including efforts to increase access through home-based PR programs.

There is evidence that healthcare providers are referring patients at very low rates in the United States and elsewhere (35). Given the nature of our dataset, we were unable to determine whether physicians fail to refer patients for PR, whether physicians refer patients for PR at different rates based on nonclinical factors (e.g., sex or race), or whether patients choose not to enroll. A recent national survey of primary care physicians found that although two-thirds reported having PR available to their patients, only 38% routinely referred their COPD patients for PR, suggesting that more needs to be done to encourage primary care physicians to recommend PR to patients who may benefit (36). Existing research suggests that one of the greatest barriers to PR referrals is a lack of knowledge of PR among providers (35). For patients, existing research indicates that transportation, current smoking, depression, fear of making a change, and not feeling well enough are barriers to PR participation (15, 37, 38). Our analysis supports the findings that transportation, current smoking, and health status are barriers for patients; more research is needed to shed light on where in the healthcare system efforts to increase PR use should be targeted.

Our study has a number of strengths. Using a 100% census sample of U.S. Medicare beneficiaries hospitalized for COPD, it is the first to examine participation in PR after a hospitalization. Unlike prior work, we were able to identify those individuals who were most likely to have moderate to severe COPD and therefore to be eligible for PR. Furthermore, we captured PR performed in both hospital-based and office-based settings. Our dataset also allowed us to observe prehospitalization factors and thus control for the severity of disease, comorbidity burden, and home oxygen use.

Although we attempted to limit our cohort to patients most likely to be eligible for PR by selecting only those who have been hospitalized for COPD exacerbations, we did not have results of spirometry, which, in addition to providing additional information on the severity of the airway obstruction, are also used to determine actual eligibility. In addition, we were unable to assess whether individuals participated in PR more than 1 year before their index admission; thus, our cohort might have included a small number of patients who had already completed PR and for whom Medicare reimbursement for PR was no longer available. The typical beneficiary is limited to 36 sessions of PR, with the potential to receive 72 sessions if their doctor documents a need for additional sessions, In addition, Medicare's limits on the number of sessions could influence referral rates if physicians are reluctant to refer patients for PR with the aim of preserving PR sessions for when the patients are more stable. This study is also limited in that we observed only elderly Medicare fee-for-service beneficiaries. Although the majority of patients hospitalized for COPD in the United States are Medicare beneficiaries (39), we cannot generalize to younger patients, in whom our findings suggest that PR receipt may be somewhat higher.

In conclusion, 2 years after Medicare began providing coverage for PR services, we found that the vast majority of individuals who might benefit from PR after a COPD hospitalization never receive these services and that this is particularly true among those who are nonwhite, female, with lower SES, and with multiple comorbidities and prior hospitalizations. To identify strategies to increase the receipt of PR and reduce disparities, more research is needed to understand the reasons that patients fail to receive PR and learn from hospitals that have been successful at enrolling patients with COPD. ■

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