Association of Part D Coverage Gap With COPD Medication Adherence

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ABSTRACT

OBJECTIVES: This study assessed the association of the Medicare Part D coverage gap with medication adherence among beneficiaries with chronic obstructive pulmonary disease (COPD).

STUDY DESIGN: Retrospective observational study based on Medicare claims data.

METHODS: A 5% random sample of Medicare claims data (2006-2010) was used in this study. Beneficiaries diagnosed with COPD and treated with long-acting bronchodilators (LABDs) were assigned to an exposure cohort (at risk of the coverage gap) or a control cohort (otherwise). The exposure and control cohorts were matched using high-dimensional propensity scores. Adherence was defined as ≥80% of the proportion of days covered by LABDs. Logistic regressions controlling for unbalanced covariates post matching were applied to assess the association of the coverage gap with adherence.

RESULTS: The final matched exposure and control cohorts each included 4147 patient-year observations with about 42% and 46% of them adherent to LABDs, respectively. About 17% of the exposure cohort hit the coverage gap after October 31. Logistic regression showed that, compared with the control cohort, the beneficiaries in the exposure cohort had a significantly lower likelihood of being adherent if they hit the coverage gap later in the year (odds ratio [OR], 0.603; 95% CI, 0.493-0.738), or had a lower likelihood without statistical significance if otherwise (OR, 0.931; 95% CI, 0.846-1.024).

CONCLUSIONS: The findings suggest that the Part D coverage gap was associated with lower adherence in patients with COPD, which may serve as evidentiary support for phasing out the coverage gap by 2020.

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Chronic obstructive pulmonary disease (COPD) is characterized by progressive airway narrowing or airflow obstruction, that causes breathing difficulties, reduced exercise capacity, and physical limitation.[1] Chronic lower respiratory disease, which primarily includes COPD, has become the third leading cause of death in the United States.[2] COPD occurs more often in females and in the elderly, with almost half of all patients with COPD being 65 years or older.[3] Pharmacotherapy is a cornerstone of COPD management, and maintenance medications are effective in controlling symptoms, maintaining lung function, and preventing COPD exacerbations.[1,4]

Previously, access to appropriate pharmacologic therapies to manage COPD was a challenge for Medicare beneficiaries due to the lack of coverage for prescription drugs. However, Part D, the Medicare prescription drug benefit, went into effect on January 1, 2006, and greatly expanded access to pharmacological therapies by subsidizing the cost of prescription drugs and prescription drug insurance premiums for Medicare beneficiaries. Pharmacologic treatments for COPD, such as bronchodilators and inhaled steroids, are now covered by Medicare Part D, with patients responsible for deductibles and co-payments. However, as per policies designed to keep the program financially sustainable, Part D does include a coverage gap for beneficiaries. Specifically, beneficiaries are financially responsible for the full cost of prescriptions once a certain dollar threshold has been reached, up to a maximum amount when catastrophic coverage begins, and then the Part D plan assumes 95% of the cost of prescriptions. These thresholds are established each year by Medicare at CMS.

In 2006[5] and in 2007,[6] approximately 1.5 million and more than 3 million beneficiaries, respectively, were estimated to reach the coverage gap. Multiple studies have assessed the effect of the coverage gap on medication adherence in elderly patients[7] and in those with different chronic diseases.[8-14] These studies have shown that the use of brand name medications significantly decreased for most conditions during the coverage gap and substituted by generic drugs. However, there were no generic versions of long-

TAKE-AWAY POINTS

- Medication adherence, in general, is not optimal in beneficiaries with chronic obstructive pulmonary disease (COPD).
- The Medicare Part D coverage gap is associated with lower adherence to COPD medication, with greater negative impact among the beneficiaries who reach the coverage gap later in the year.
- The timing of reaching the Part D coverage gap has effects on the level of medication adherence.

acting bronchodilators (LABDs) available as a long-term maintenance therapy for COPD in the United States. No published studies have evaluated the effect of the Part D coverage gap on medication utilization among Medicare beneficiaries with COPD or explored whether patients in the coverage gap may behave differently due to the lack of generic options. This omission is problematic given the high prevalence of COPD among the elderly[3] and the negative health and economic consequences of nonadherence.[15,16] Therefore, the objective of this study was to assess the association between the Part D coverage gap among Medicare beneficiaries diagnosed with COPD and their adherence to COPD maintenance medications, LABDs.

METHODS

Data Source

A 5% random sample of Medicare beneficiaries was used for this study. The Medicare administrative claims database is a comprehensive data source covering all beneficiaries who were enrolled in Medicare, capturing information on demographic characteristics, enrollment, prescription drug events, medical encounters in inpatient and outpatient settings, and health services incurred in other facilities, such as hospice or skilled nursing homes. This study was approved by the institutional review board and by the CMS Privacy Board.

Sample Selection

Inclusion and exclusion criteria. Because the coverage gap thresholds varied by calendar year, patient selection and outcome measures were employed at a calendar-year level. Considering that many Medicare beneficiaries did not have a full-year benefit in 2006, only data files from 2007 to 2010 were used for analysis, and the 2006 data file was used to describe patient baseline characteristics. Beneficiaries who met all of the following inclusion criteria were selected to form a general patient pool: a) had "of age" listed as the reason for Medicare eligibility (ie, age is ≥65 years as of 6 months prior to January 1 of a calendar year), b) had a full year's eligibility during a respective calendar year and 6 months of eligibility prior to January 1 of the respective calendar year (the 6 months were defined as baseline period), c) had at least 2 outpatient claims with a diagnosis of COPD on different dates or at least 1 emergency department (ED) or inpatient claim with COPD as the primary diagnosis during a respective calendar year, and d) had at least 2 prescriptions for LABDs filled on different dates during a respective calendar year (LABDs are listed in **eAppendix Table 1** [eAppendices available at **www.ajmc.com**]).

Beneficiaries were excluded from the study if they met at least 1 of the following criteria: a) were enrolled with a Medicare Advantage plan in any month during a respective calendar year; b) had a diagnosis of asthma during a respective calendar year, because some of the LABD medications are also indicated for asthma; c) had a diagnosis of cancer during a respective calendar year, because patients with cancer likely have different medication utilization and spending patterns compared with other Medicare beneficiaries; or d) had a disability or end-stage renal disease during a respective calendar year, because the benefits of such patients can differ substantially from those of other Medicare beneficiaries.

Study Cohorts

Beneficiaries who met the above selection criteria were divided into 2 study cohorts.

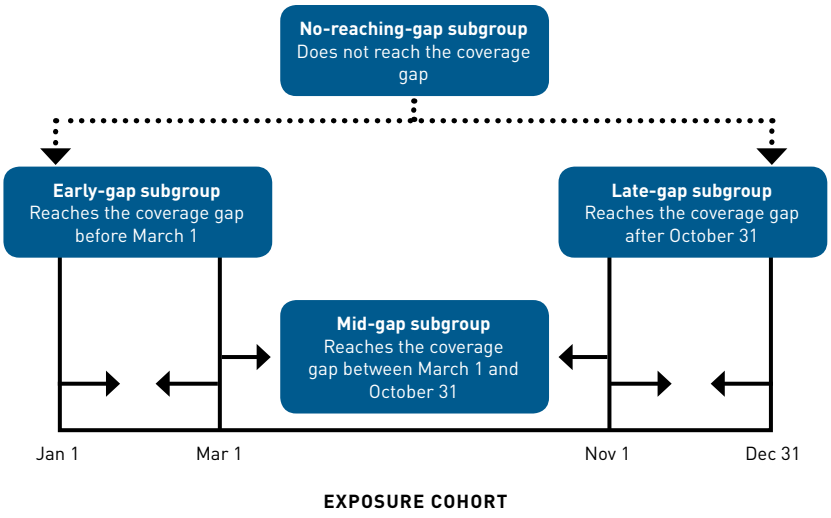
Control cohort. Beneficiaries were assigned to the control cohort if they fell into 1 of the following categories: a) had Medicare-Medicaid dual eligibility for the whole year, b) qualified for Part D low-income subsidies (LIS) (ie, received LIS for at least 1 month before and after they entered the coverage gap), or c) had additional benefits covering brand and generic drugs during the gap.

Exposure cohort and subgroups in exposure cohort. If beneficiaries did not have dual eligibility or low-income subsidies or full benefits to help with the coverage gap during a calendar year, they were assigned to the exposure cohort.

The exposure cohort was further categorized into 4 subgroups. Beneficiaries who did not reach the coverage gap in a respective year were identified as "no-reaching-gap subgroup." This subgroup was not included in the final exposure cohort based on the assumption that beneficiaries who were relatively healthy were much less likely to reach the coverage gap; therefore, their medication-taking behavior was not expected to noticeably change as a result of presence of the coverage gap. Beneficiaries who reached the coverage gap before March 1 were identified as the "early-gap subgroup." Similar to the "no-reaching-gap subgroup," the early-gap subgroup was not included in the final exposure cohort based on the assumption that beneficiaries who reached the coverage gap early may have been very sick and wanted to maximize their medication usage during the gap period to enter the catastrophic phase sooner. This group of patients was anticipated to be small and to respond to the coverage gap differently than other subgroups.

Beneficiaries who reached the coverage gap between March 1 and October 31 were identified as the "mid-gap subgroup." Finally, beneficiaries who reached the coverage gap on or after November 1 were identified as the "late-gap subgroup." Thus, the final exposure cohort only included the mid-gap and the late-gap subgroups. **Figure 1** depicts the subgroup designation within the exposure cohort.

FIGURE 1. Subgroups of the Exposure Cohort



Variables

Adherence was measured as the proportion of days covered (PDC). Yearly PDC was defined as the proportion of days covered by LABDs relative to the treatment period during a calendar year. The treatment period was calculated as the duration from the fill date of the first LABD prescription until the end of the year. A dichotomous variable for adherence was constructed as 1 if PDC ≥80%, and 0 otherwise.

The independent variable of interest was a dichotomous indicator of membership in the exposure or the control cohort (1 = exposure cohort, 0 = control cohort). In addition, the following demographic and clinical variables in the baseline period were also assessed: age, gender, ethnicity, residence region, Charlson Comorbidity Index (CCI) score (**eAppendix Table 2**), presence of major comorbidities (eg, diabetes, heart disease) (specified in **eAppendix Table 3**), number of unique prescription drugs defined by the first 9 digits of the national drug codes, number of all-cause ED visits, number of all-cause inpatient visits, previous COPD diagnosis, previous use of LABDs, previous supplemental oxygen therapy (**eAppendix Table 4**), and previous use of oral corticosteroids (**eAppendix Table 5**).

High-Dimensional Propensity Score Matching

In observational studies, selection bias is an important issue when comparing groups and exposure is not randomly assigned. Propensity score matching (PSM) is commonly used to generate comparable exposure and control cohorts with balanced demographic and clinical characteristics. In a traditional approach to generating propensity scores, a number of relevant confounders or covariates included in a logistic model are defined based on available data, and they are primarily guided by knowledge related to exposure and the study population characteristics. In a typical claims database, important attributes are unavailable (eg, laboratory results, functional status, smoking status, over-the-counter medication); therefore, empirically identifying appropriate proxies for patient health status out of a large number of variables in claims data is a significant challenge. High-dimensional propensity score (HDPS) analysis is an automated algorithm developed by Schneeweiss and colleagues (2009) to set up proxies by assessing diagnosis codes, procedure codes, and prescribed medication codes,[17] which helps to overcome the aforementioned challenges in the process of reducing selection bias and controlling for confounding effects.

HDPS analysis was employed in this study with the diagnosis code and the procedure codes in outpatient, ED, and inpatient settings specified as data dimensions. In each data dimension, the 200 most prevalent codes were used, and then the possible amount of confounding was calculated for each variable based on a multiplicative model to sort all variables in a descending order. The top 300 variables were selected to construct a logistic model and generate the propensity score.[17,18] Lastly, PSM was conducted at 1:1 between the exposure cohort and the control cohort using the Greedy 5-to-1 digit technique.[19]

Statistical Analysis

Before matching, the Student's *t* tests were used to detect differences in patient characteristics between the exposure and the control cohorts for continuous variables (eg, age, CCI score), and the χ^2 test was used for categorical variables, including demographics (eg, gender, ethnicity) and comorbidities (eg, diabetes, hypertensive disease). After matching, McNemar's tests were used for categorical variables and the paired *t* test for continuous variables.

Multivariable Analysis

After matching, a conditional logistic regression model was constructed with adherence (1 if PDC ≥80%, 0 if PDC <80%) as the dependent variable. More than 50% of the beneficiaries had repeated observations for 2 or more years from 2007 to 2010. Therefore, a generalized estimating equation technique was applied in the multivariable models to correct for the correlation between repeated observations of a patient.[20,21] All analyses were performed using

TABLE 1. Sample Size of Study Cohorts and Subgroups[a]

Before Matching	Year				Total
	2007	2008	2009	2010	
Enrolled with Part D: not exposed to Part D coverage gap	1011	1012	1145	1176	4344
Enrolled with Part D: exposed to Part D coverage gap	4191	4487	4675	4920	18,273
No-reaching-gap subgroup	1372	1700	1930	2149	7151
Reached the gap	2819	2787	2745	2771	11,122
1) Early-gap subgroup	33	41	24	20	118
Entered the catastrophic phase	29	39	22	19	109
2) Mid-gap subgroup	2305	2271	2203	2231	9010
Entered the catastrophic phase	511	504	483	469	1967
3) Late-gap subgroup	481	475	518	520	1994
Entered the catastrophic phase	1	0	0	0	1
Final exposure cohort (mid-gap + late-gap) before matching	2786	2746	2721	2751	11,004
Final control cohort before matching	1011	1012	1145	1176	4344
After Matching	**Year**				**Total**
	2007	2008	2009	2010	
Matched exposure cohort	987	970	1087	1103	4147
1) Mid-gap subgroup	821	804	896	912	3433
Entered the catastrophic phase	216	227	228	248	919
2) Late-gap subgroup	166	166	191	191	714
Entered the catastrophic phase	0	0	0	0	0
Matched control cohort	987	970	1087	1103	4147

[a]Early-gap subgroup indicates entering the coverage gap before March 1; mid-gap subgroup, entering the coverage gap between March 1 and October 31; late-gap subgroup, entering the coverage gap on, or after, November 1.

SAS version 9.2 (SAS Institute Inc, Cary, North Carolina). *P* values less than .05 were considered to be statistically significant.

RESULTS

Sample Size

Application of the patient selection criteria resulted in 5366, 5650, 5991, and 6268 unique beneficiaries diagnosed with COPD and treated with LABDs for the years 2007 to 2010, respectively (**Table 1**). **Figure 2** depicts the patient selection flow and the sample size at different steps. Each year, nearly 20% of those beneficiaries enrolled with Part D benefit were not subject to the coverage gap (ie, assigned into the control cohort), and the remaining beneficiaries were at risk of the coverage gap (ie, assigned into the overall exposure cohort).

From 2007 to 2010, respectively, the final control cohort contained 1011, 1012, 1145, and 1176 beneficiaries, and the final exposure cohort (the mid-gap + the late-gap subgroups) contained 2786, 2746, 2721, and 2751 beneficiaries. Combined across all years, there were 4344 patient-year observations in the control cohort and 11,004 patient-year observations in the exposure cohort before implementation of PSM. After the 1:1 matching, both cohorts included 4147 patient-year observations, which was the final sample for analysis.

Descriptive Analysis

Overall, the mean age of the patients was 77.4 years (standard deviation [SD] = 7.6), the majority (71%) was female, and more than 90% were Caucasians (**Table 2**). Beneficiaries were heavily concentrated in the South, while beneficiaries in the West were underrepresented in the study. The mean CCI score was approximately 2.2. The most common comorbidity in the baseline period was hypertension (>65%), followed by heart disease (>50%) and hyperlipidemia (>45%). More than 70% of the patients had used a LABD, and a large proportion of them received oxygen therapy or oral corticosteroids (about 30%) in the baseline period. Beneficiaries had substantial medication burden in the baseline period, with an average of more than 10 different classes of medications.

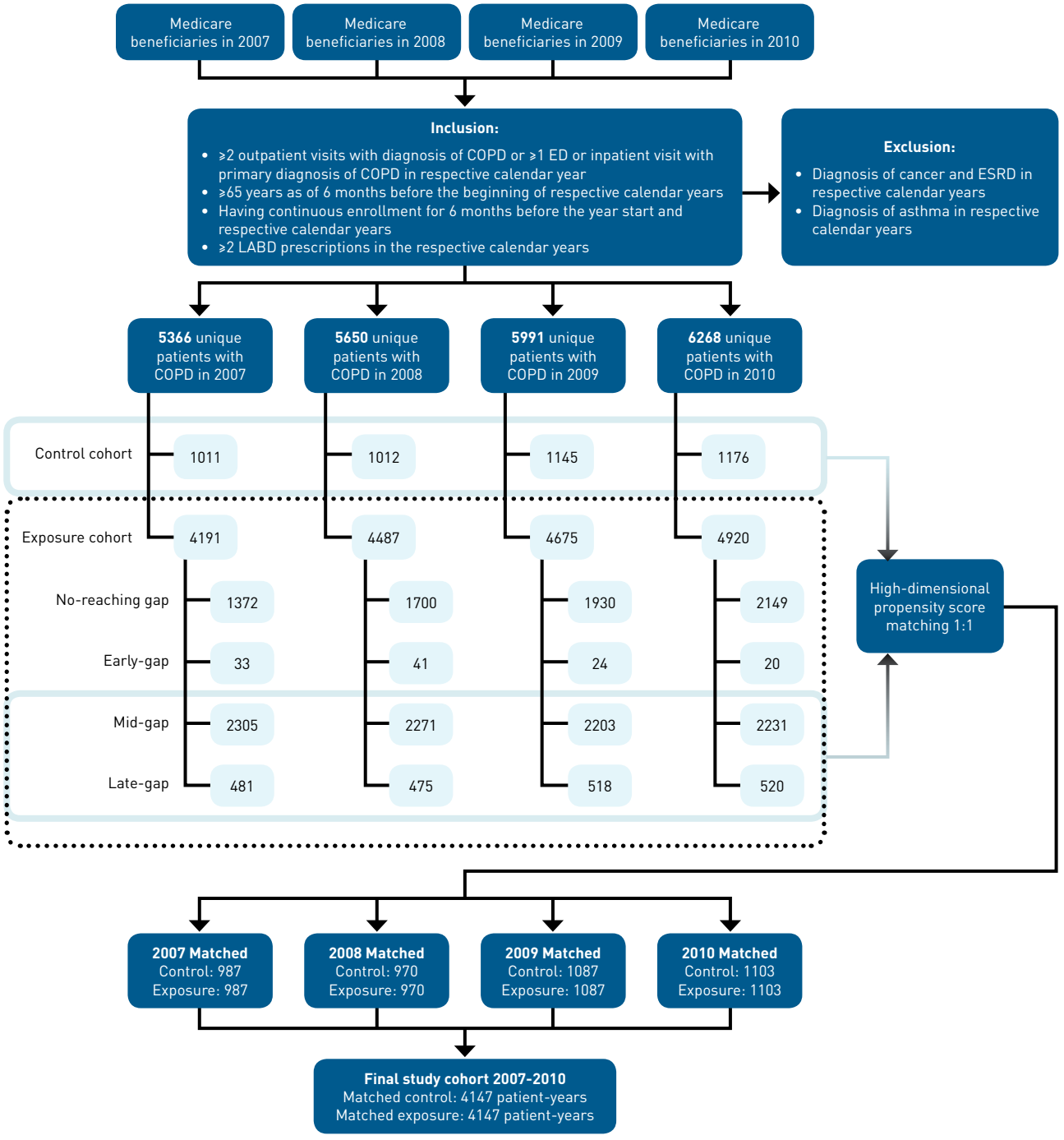
Prior to matching, the control and the exposure cohorts were significantly different in almost all of the demographic and baseline characteristics, except for several baseline comorbidities. After matching, the cohorts were generally balanced in demographic and baseline characteristics, with statistical differences observed only for the prevalence of several baseline comorbidities. The standardized differences were generally small, with most of the absolute values less than 10% (except several baseline comorbidity variables), indicative of acceptable balance between the matched cohorts.[22]

After cohort matching, the mean annual PDC in the matched control cohort was 0.70 (SD = 0.25); it was 0.69 (SD = 0.24) in the matched exposure cohort. About 46% of the matched control cohort was adherent versus 42% for the matched exposure cohort.

Multivariable Analysis

Unadjusted results showed the matched exposure cohort had lower adherence rates than the matched control cohort. After adjusting for age, gender, and the unbalanced covariates, beneficiaries who reached the coverage gap had lower odds of adherence compared with beneficiaries who were not exposed to the coverage gap. Specifically, beneficiaries in the late-gap subgroup

FIGURE 2. Patient Selection Flowchart



COPD indicates chronic obstructive pulmonary disease; ED, emergency department; ESRD, end-stage renal disease; LABD, long-acting bronchodilator.

had nearly 40% lower odds of adherence than beneficiaries in the control cohort (OR, 0.603; 95% CI, 0.493-0.738). Beneficiaries in the mid-gap subgroup also had lower odds of adherence, although this relationship was not statistically significant (OR, 0.931; 95% CI, 0.846-1.024). In addition, hyperlipidemia, depression, and diseases of the musculoskeletal system and connective tissues were found to be associated with lower likelihood of adherence ($P < .05$) (**Table 3**).

TABLE 2. Patient Demographics and Baseline Characteristics of Study Cohorts Before and After Matching[a]

	Before Matching			After Matching			
	Control (n = 4344)	Exposure (n = 11,004)	*P*	Control (n = 4147)	Exposure (n = 4147)	*P*[b]	Std Diff in %
Age, years: mean (SD)	77.41 (7.64)	76.59 (7.22)	<.0001	77.38 (7.64)	77.31 (7.46)	.9081	−0.93
Female, n (%)	3114 (71.69)	7187 (65.31)	<.0001	2963 (71.45)	2933 (70.73)	.4675	−1.60
Caucasian, n (%)	4008 (92.27)	10,744 (97.64)	<.0001	3925 (94.65)	3912 (94.33)	.5316	−1.37
Region, n (%)			<.0001			.1259	
Northeast	1121 (25.81)	2485 (22.58)		1064 (25.66)	1025 (24.72)		−2.17
Midwest	1363 (31.38)	2583 (23.47)		1291 (31.13)	1311 (31.61)		1.04
West	226 (5.2)	1473 (13.39)		226 (5.45)	284 (6.85)		5.82
South	1632 (37.57)	4457 (40.5)		1564 (37.71)	1525 (36.77)		−1.95
Charlson Comorbidity Index score in the baseline period, mean (SD)	2.22 (1.69)	1.87 (1.44)	<.0001	2.16 (1.63)	2.17 (1.65)	.975	0.61
Other comorbidities in the baseline period, n (%)							
Asthma	429 (9.88)	1079 (9.81)	.8953	405 (9.77)	457 (11.02)	.0613	4.11
Hyperlipidemia	1970 (45.35)	5223 (47.46)	<.0001	1881 (45.36)	2294 (55.32)	**<.0001**	20.02
Heart disease	2480 (57.09)	5633 (51.19)	<.0001	2331 (56.21)	2353 (56.74)	.6261	1.07
Deficiency anemia	1035 (23.83)	1793 (16.29)	<.0001	952 (22.96)	828 (19.97)	**.0009**	−7.29
Depression	768 (17.68)	1119 (10.17)	<.0001	717 (17.29)	526 (12.68)	**<.0001**	−12.93
Anxiety	462 (10.64)	770 (7)	<.0001	443 (10.68)	353 (8.51)	**.0027**	−7.37
Osteoporosis	584 (13.44)	1533 (13.93)	.4302	552 (13.31)	608 (14.66)	.0763	3.89
Osteoarthritis	998 (22.97)	2076 (18.87)	<.0001	928 (22.38)	918 (22.14)	.7918	−0.58
GERD	869 (20)	1554 (14.12)	<.0001	819 (19.75)	683 (16.47)	**.0001**	−8.52
Sleep disorder	236 (5.43)	881 (8.01)	<.0001	217 (5.23)	367 (8.85)	**<.0001**	14.17
Diseases of the musculoskeletal system and connective tissue	1739 (40.03)	3570 (32.44)	<.0001	1624 (39.16)	1532 (36.94)	**.0375**	−4.57
Hypertensive disease	2998 (69.01)	7170 (65.16)	<.0001	2828 (68.19)	2921 (70.44)	**.0268**	4.86
Obesity	182 (4.19)	378 (3.44)	.0247	159 (3.83)	177 (4.27)	.3161	2.20
Prevalent COPD diagnosis in the baseline period, n (%)	3625 (83.45)	9370 (85.15)	.0084	3461 (83.46)	3491 (84.18)	.3711	1.96
Prescribed with LABDs in the baseline period, n (%)	3204 (73.76)	8339 (75.78)	.0089	3073 (74.1)	3023 (72.9)	.2135	−2.73
Prescribed with oral corticosteroids in the baseline period, n (%)	1237 (28.48)	3037 (27.6)	.2749	1175 (28.33)	1173 (28.29)	.9611	−0.11
Order of oxygen therapy in the baseline period, n (%)	1273 (29.30)	3811 (34.63)	<.0001	1245 (30.02)	1252 (30.19)	.8669	0.37
Number of unique prescription drugs in the baseline period, mean (SD)	11.95 (7.25)	10.02 (5.63)	<.0001	11.59 (6.85)	11.69 (6.35)	.0933	1.51
Number of all-cause ED visits in the baseline period, mean (SD)	0.43 (0.87)	0.33 (0.78)	<.0001	0.42 (0.84)	0.44 (0.98)	.5431	2.19
Number of all-cause inpatient visits in the baseline period, mean (SD)	0.33 (0.72)	0.27 (0.66)	<.0001	0.32 (0.71)	0.34 (0.76)	.9636	2.72

COPD indicates chronic obstructive pulmonary disease; ED, emergency department; GERD, gastroesophageal reflux disease; LABD, long-acting bronchodilator; SD, standard deviation; std diff, standardized difference.
[a]The baseline period was defined as 6 months prior to the start of a calendar year.
[b]Bolding indicates significance.

DISCUSSION

The study results suggest that reaching the Part D coverage gap may be negatively associated with medication adherence among Medicare patients with COPD, and the association was stronger among the beneficiaries who reach the coverage gap later (ie, on or after November 1). One explanation for these findings may be that when Medicare beneficiaries enter the coverage gap, they

bear a higher economic burden to obtain their medications and they may be more likely to choose nonadherence to more expensive brand name drugs. In addition, we assessed patients' use of short-acting bronchodilators (SABDs) before and after they hit the coverage gap and did not observe a remarkable shift (results not reported here). One possible reason is that SABDs are a class of medications that are usually used to relieve acute symptoms, not a substitute for long-term maintenance therapy.

The results are consistent with previous studies finding that the Part D coverage gap is associated with reduced medication adherence.[23-26] For example, Fung et al (2010) found that the odds of adherence among patients with diabetes with the Part D coverage gap decreased by 17% compared with those patients without the Part D coverage gap.[23] Likewise, Stuart and colleagues (2013) found that the PDC was 7.8% lower for statins, 7.0% lower for clopidogrel, or 5.9% lower for beta-blockers for beneficiaries exposed to the coverage gap compared with those not exposed.

To date, this is the first study to evaluate the impact of the Part D coverage gap on medication adherence for beneficiaries with COPD using the longitudinal national Medicare claims data, and it is 1 of few studies to explore the impact of hitting the coverage gap at different times of the year.[8,27,28] In contrast, most research has assessed the impact of the coverage gap from the perspective of in versus out of the coverage gap. Our study suggests that such temporal distinctions may have important implications for patient behaviors, such as adherence to prescription drugs.

Another strength of this study is that the high-dimensional PSM was adopted to mitigate potential selection biases and to adjust for the observed confounding effect between the exposure and the control cohorts, which extends beyond traditional PSM by maximizing the utilization of the information provided by claims data. Compared with traditional PSM methods that use "typical" covariates only (eg, age, gender, comorbidities), matching 2 cohorts in this way may provide estimates closer to those of randomized trials.[17]

This study has several limitations. First, the medical and pharmacy claims data used in this analysis were primarily used for administrative purposes to obtain reimbursement; therefore, there is potential for coding errors that may cause diagnostic and procedural misclassification. In addition, adherence was measured based on the assumption that patients took the drugs after they filled the prescriptions when using pharmacy claims data.

Second, the study is subject to the limitations of retrospective observational studies, and the findings can only be interpreted as association and no causality can be concluded. Although multiple strategies were applied to minimize selection bias and confounding effects, they were unable to control for unobserved factors (eg, health literacy level) or beneficiary behaviors (eg, self-selection of a high-premium plan to avoid or reduce the burden produced by the coverage gap).

TABLE 3. Conditional Logistic Regression on Adherence to LABDs

Variable	OR	95% CI	*P*[a]
Mid-gap exposure subgroup (vs control cohort)	0.931	0.846-1.024	.1415
Late-gap exposure subgroup (vs control cohort)	0.603	0.493-0.738	**<.0001**
Age, years	1.005	0.998-1.013	.1809
Female (vs male)	1.104	0.967-1.261	.1425
Hyperlipidemia	0.869	0.774-0.975	**.0172**
Deficiency anemia	1.034	0.899-1.189	.6374
Depression	0.848	0.721-0.997	**.0463**
Anxiety	0.974	0.798-1.188	.7927
GERD	1.057	0.913-1.224	.4568
Sleep disorder	0.981	0.793-1.215	.8622
Diseases of the musculoskeletal system and connective tissue	0.809	0.719-0.911	**.0004**
Hypertensive disease	0.970	0.852-1.105	.6502

GERD indicates gastroesophageal reflux disease; LABD, long-acting bronchodilator; OR, odds ratio.
[a]Bolding indicates significance.

Third, COPD patients in the exposure cohort who did not reach the coverage gap or reached the gap prior to March 1 were excluded from the analysis, assuming the 2 groups represent the 2 extremes of the spectrum of health status. No similar exclusion was done for the control cohort not exposed to the coverage gap. However, we believe that the use of HDPS analysis provides some assurance of the comparability of the 2 cohorts. Nevertheless, future research that takes into consideration the beneficiaries with very low drug spending who were subjected to the coverage gap may help to further balance the comparative cohorts.

Lastly, the study cohort was composed of beneficiaries from the Medicare fee-for-service program, so the results might not be generalizable to the Medicare population enrolled with Medicare Advantage plans. Similarly, the study period ended in 2010 due to data availability, and it is not clear if the effect of the coverage gap identified in this study remained after 2010. Studies of the Medicare managed care population or studies using more recent data could provide additional insights into these issues.

Medicare benefit cycles restart at the beginning of each calendar year. Beneficiaries are aware of the coverage gap at that time and have an anticipation of the likelihood of hitting the gap during the year. Although being adherent is likely to lead beneficiaries to enter the coverage gap or enter the gap earlier, the effect of the coverage gap is larger from a perspective of behavior adjustment, based on information and projection.

The coverage gap is planned to close out by 2020. At that point, beneficiaries will pay 25% of the total cost for covered brand name and generic drugs during the gap. Although the cost of closing the coverage gap may present a serious challenge to policy

makers in the current fiscal climate, it is expected that the coverage gap closure will benefit beneficiaries. Prior to the close-out of the Part D coverage gap, healthcare administrators and health plans should make efforts to help beneficiaries transition through the gap smoothly and minimize the risk of experiencing high out-of-pocket costs and preventable adverse outcomes from medication nonadherence. Health plans can take more proactive approaches to raising awareness of the coverage gap among beneficiaries and physicians, and providing beneficiaries with personalized information on cost-saving options that may help delay their entry into the gap. Health plans and policy makers may also want to consider educating beneficiaries, in collaboration with healthcare providers, about the importance of adherence to help patients remain compliant with their medication regimens.

CONCLUSIONS

Findings from this study revealed that reaching the Part D coverage gap is associated with lower odds of medication adherence among Medicare beneficiaries with COPD. Building on these results, additional research related to other important illnesses or other meaningful outcomes will be pertinent for increasing the knowledge base in this area, improving current benefit design, and optimizing the quality of health policy decisions to help Medicare provide optimal healthcare for its members with cost-effective outcomes.

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eAppendix

eAppendix Table 1. Maintenance Medications Used for COPD

Class	Medication Generic Names
LABD medications	• Arformoterol
	• Formoterol
	• Indacaterol
	• Salmeterol
	• Tiotropium
	• Budesonide + formoterol
	• Fluticasone + salmeterol
	• Mometasone + formoterol
SABD medications	• Albuterol + ipratropium
	• Ipratropium
	• Levalbuterol
	• Metaproterenol
	• Pirbuterol
	• Albuterol or salbutamol

COPD indicates chronic obstructive pulmonary disease; LABD, long-acting bronchodilator; SABD, short-acting bronchodilator.

eAppendix Table 2. *ICD-9-CM* Diagnosis Codes for CCI Conditions[a]

CCI Conditions	*ICD-9-CM* Diagnosis Codes
Myocardial infarction	410.x, 412.x
Congestive heart failure	428.x
Peripheral vascular disease	443.9, 441.x, 785.4, V43.4
Cerebrovascular disease	430-438.x
COPD	490-496.x, 500-505.x, 506.4
Dementia	290.x
Paralysis	342.x, 344.1x
Diabetes	250.0x – 250.3x, 250.7x
Diabetes with sequela	250.4x – 250.6x, 250.8x, 250.9x
Moderate or severe renal disease	582.x, 583.x, 585.x, 586.x, 588.x
Mild liver disease/various cirrhosis	571.x
Moderate or severe liver disease	572.x, 456.x
Ulcer disease	531-534.x
Rheumatologic disease	710.x, 714.x, 725.x
AIDS	042.x – 044.x
Any tumor	140-195.x
Metastatic solid tumor	196-199.x

CCI indicates Charlson Comorbidity Index; COPD, chronic obstructive pulmonary disease; *ICD-9-CM*, *International Classification of Diseases, Ninth Revision, Clinical Modification*.
[a]Created based on Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with *ICD-9-CM* administrative databases. *J Clin Epidemiol*. 1992;45(6):613-619.

eAppendix Table 3. *ICD-9-CM* Diagnosis Codes for Major Comorbidities

Chronic Condition or Disease Class	***ICD-9-CM* Diagnosis Codes**
Asthma	493.xx
Diabetes	250.xx
Hypertensive disease	401.xx-405.xx
Heart disease	410.xx-429.xx
Cerebrovascular disease	430.xx-438.xx
Depressive disorder	296.2x, 296.3x, 300.4, 311
Anxiety	293.84, 300.0x, 300.21, 300.22 300.23, 300.29, 300.3x, 300.5x, 300.89, 300.9x, 308.xx 309.81, 313.0x, 313.1x, 313.21, 313.22, 313.3x, 313.82, 313.83
Diseases of the musculoskeletal system and connective tissue	710.xx-719.xx
Deficiency anemia	281.xx, 285.xx
Lipid disorder	272.0x, 272.1x, 272.2x, 272.3x, 272.4x
Osteoporosis	733.0x, V17.81
Osteoarthritis	715.xx V13.4 (arthritis)
GERD	530.81, 530.10, 530.11, 530.12, 530.19
Sleep apnea	780.51, 780.53, 780.57, 327.20, 327.21, 327.23, 327.27, 327.29
Obesity	278.xx, V77.8, V85.2-V85.5

GERD indicates gastroesophageal reflux disease; *ICD-9-CM*, *International Classification of Diseases, Ninth Revision, Clinical Modification*.

eAppendix Table 4. Procedure Codes for Supplemental Oxygen Therapy

Supplemental Oxygen Therapy	Description
ICD-9-CM procedure code: V46.2	Machine-dependent supplemental oxygen
HCPCS codes:	
E0431	Compressed-oxygen systems
E1390, E1391	Oxygen concentrator
E1392	Portable oxygen concentrator

HCPCS indicates Healthcare Common Procedure Coding System; *ICD-9-CM*, *International Classification of Diseases, Ninth Revision, Clinical Modification*.

eAppendix Table 5. Oral Corticosteroids

Brand Name	Generic Name
Diprolene, Betaderm, Betnovate, Diprosone	Betamethasone
Decadron, Maxidex, Ozurdex, Baycadron	Dexamethasone
Cortenema, Solu-cortef, Cortef, Cortifoam	Hydrocortisone
Medrol Dosepak, Solu-Medrol, Medrol, MethylPREDNISolone	Methylprednisolone
Deltasone, Sterapred, Rayos, Sterapred DS	Prednisolone
Deltasone, Sterapred, Rayos, Sterapred DS	Prednisone
Kenalog-40, Aristocort, Azmacort, Kenalog-10	Triamcinolone
Cortone	Cortisone Acetate
Depo-Dilar	Paramethasone