High-risk Diabetic Patients in Medicare Part D Programs: Are They Getting the Recommended ACEI/ARB Therapy?

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BACKGROUND: Diabetes patients with hypertension and/or renal disease are at an increased risk of cardiovascular morbidity and mortality. Clinical evidence suggests that the use of ACEI/ARB for these patients improves patient outcomes.

OBJECTIVE: To describe ACEI/ARB utilization among high-risk patients with diabetes and to identify patient characteristics that predict suboptimal utilization of ACEI/ARB.

DESIGN: A retrospective cohort study.

PATIENTS: Diabetic patients with coexisting hypertension and/or renal disease with continuous Medicare coverage from October 1, 2005 through June 30, 2006 in six states (Alabama, California, Florida, Mississippi, New York, and Ohio).

INTERVENTIONS AND MEASUREMENTS: Any ACEI/ARB use during the first 6 months of 2006.

RESULTS: A total of 1,250,466 Medicare Part D enrollees met our inclusion criteria. ACEI/ARB utilization rates were 63%, 58.3%, and 43.1% among diabetic patients with hypertension and renal disease, hypertension without renal disease, and renal involvement without hypertension, respectively. After adjusting for all other characteristics studied, patients in the hypertension only (OR 0.83; 95% CI: 0.82–0.84) and renal disease only (OR: 0.48; 95% CI: 0.46–0.50) risk groups were less likely to use ACEI/ARB compared to diabetes patients with both hypertension and renal disease. Several demographics, including male gender, age older than 65, and white race, were all predictors of suboptimal ACEI/ARB use. Results from state-specific analyses are consistent with those for all six states.

CONCLUSION: In this cohort, less than 60% of high-risk patients with diabetes were receiving the recommended ACEI/ARB therapy. Several patient demographic and clinical characteristics are strongly associated with suboptimal ACEI/ARB use.

KEY WORDS: diabetes; ACEI/ARB; hypertension; renal disease; Medicare Part D.

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INTRODUCTION

National survey data indicate that the incidence of diabetes among adults in the US nearly doubled over the past 10 years, with age-adjusted incidence increased from 4.8 per 1,000 in 1995–1997 to 9.1 per 1,000 in 2005–2007.¹ Hypertension is an extremely common comorbid condition of diabetes, occurring in 75% of adults with diabetes. Hypertension represents a serious clinical risk factor for diabetic macrovascular complications, such as coronary artery disease, heart failure, and stroke, which in turn account for over 80% of diabetes-related mortality among people aged 65 years or older.² Hypertension is also a major risk factor for developing diabetes-related microvascular complications such as retinopathy and nephropathy. Diabetic nephropathy affects 20–40% of individuals with diabetes and is the single leading cause of end-stage renal disease (ESRD) in the US.

A number of clinical trials and epidemiological studies have concluded that lowering of blood pressure can substantially reduce the risk of diabetes-related morbidity and mortality.^{3–5} For example, the UK Prospective Diabetes Study (UKPDS) demonstrated that tight blood pressure control in patients with diabetes can significantly reduce the risk of diabetes complications, with each 10-mmHg decrease in mean systolic blood pressure associated with a 12% reduction in the risk of any complications related to diabetes.³ A 10-year follow-up of the UKPDS patients suggested that long-term optimal blood pressure control with regimens based on antihypertensive medications is the key to achieving the greatest benefit.⁶ A variety of antihypertensive agents, including angiotensin converting enzyme inhibitors (ACEIs), angiotensin II receptor blockers (ARBs), β -blockers, diuretics, and calcium channel blockers, have all been shown to be effective in preventing diabetes-related complications.^{7–9} Several clinical trials have suggested that ACEIs and ARBs, in addition to controlling blood pressure, can attenuate renal disease progression through the inhibition of the renin-angiotensin-aldosterone system,^{10–15} a mechanism that is independent of blood pressure reduction. Based on compelling evidence, the American Association of Clinical Endocrinologists, the American Diabetes Association, and the National Kidney Foundation

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recommend that all patients with diabetes and comorbid hypertension and/or renal disease be treated with an antihypertensive regimen including either an ACEI or an ARB.⁷⁻⁹ If one class is not tolerated, the other should be substituted. In actual practice, however, ACEI/ARB has been substantially underused among high-risk diabetic patients.¹⁶⁻¹⁸

Hypertension and/or renal disease are known clinical risk factors for patients with diabetes. The presence of either one or both of these factors places patients at substantially greater risk of diabetes-related morbidity and mortality.^{2,19,20} In these patients, appropriate utilization of ACEI/ARB is especially important. In this study, we used Medicare Part D claims data to assess the utilization of ACEI/ARB among a large cohort of high-risk patients with diabetes, i.e., patients with diabetes and comorbid hypertension and/or renal diseases. Our specific objectives were to (1) describe ACEI/ARB utilization among high-risk patients with diabetes and (2) identify patient characteristics that predict suboptimal utilization of ACEI/ARB. For the purpose of this study, ACEI/ARB utilization was measured with at least one filled prescription for ACEI/ARB, a measure commonly used in medication utilization studies with claims data.

METHODS

Patients

This is a retrospective cohort study. The study sample included Medicare Part D enrollees from six states (Alabama, California, Florida, Mississippi, New York, and Ohio) who had diabetes and coexisting hypertension and/or renal disease, and who had continuous Medicare coverage from October 1, 2005 through June 30, 2006. These states were included because they are geographically dispersed and provide a cross-sectional representation of the US. In addition, these states (particularly California, New York, and Florida) contain large numbers of Medicare beneficiaries, ensuring that we obtained an adequate number of beneficiaries with diabetes. Alabama and Mississippi were included because they have the highest prevalence of diabetes in people over 65 years.²¹ Patients who did not have a single prescription claim in Part D were excluded. Patients with missing prescription service date/product service date in Part D data were also excluded to ensure that we did not include beneficiaries not enrolled in Part D.

Medicare Part D prescription drug claims data for enrollees from the aforementioned six states from January 1, 2006 to June 30, 2006 were retrieved for this study. To assist patient identification, Medicare Part A (hospital inpatient, hospice care, and home health care) and Part B (physicians, outpatient, physical or occupational therapists) claims and Medicare beneficiary files were also retrieved. Medicare Part A, B, and D data and beneficiary files were linked through a unique patient identification number. Data were checked for duplicates. In the case of duplicate claims, only the first of all duplicated records was retained. This study was approved by the University of Mississippi Institutional Review Board.

Diabetic patients were identified if they had (1) at least one *International Classification of Diseases, Ninth Revision (ICD-9)* code for diabetes (250.xx) in Medicare medical claims from October 1, 2005 through June 30, 2006; or (2) at least one claim of insulin ≥ 10 ml in total; or (3) two or more claims for any oral hypoglycemic agent (OHG); or (4) at least one claim for

over 30 days' supply for any OHG in Medicare Part D data from January 1, 2006 to June 30, 2006. Hypertension was identified with ICD-9 code 401, and renal diseases were identified with ICD-9 code for nephropathy (582.81, 582.9), proteinuria (791.0), and diabetic nephropathy (250.4) from Medicare Part A and Part B claims data between October 1, 2005 and June 30, 2006. We categorized all study subjects into three mutually-exclusive groups based on their risk profile: (1) diabetes with comorbid hypertension and renal disease; (2) diabetes with hypertension but no renal involvement; and (3) diabetes with renal disease but no hypertension.

Outcome Measure

The outcome of interest was any ACEI/ARB use, measured by at least one filled prescription for any ACEI/ARB between January 1, 2006 and June 30, 2006. Pharmacy claims for ACEI/ARB were identified by matching the drug claims in Part D with National Drug Codes of ACEIs and ARBs obtained from the Multum drug database.

Potential Predictors of Suboptimal ACEI/ARB Use

Several patient demographic and clinical characteristics were included as potential predictors of suboptimal ACEI/ARB use. The selection of predictors was informed by previous studies of chronic medication use in patients with diabetes.^{16-18,22,23} Demographic variables included patient age, sex, and race. Having one or more claims for diabetes-related medical services for our study sample in Part A (including Part A plus Part B and Part A only) or Part B data only was used as a proxy measure of disease severity. Diabetes-related services were identified using primary and secondary ICD-9 codes of 250.xx in Medicare Part A and Part B claims data. This variable was categorized into three groups: any Part A, Part B only, and neither Part A nor Part B.

Clinical predictors include major diabetes comorbid conditions and complications of diabetes. Diabetes comorbid conditions and complications were identified based on medical claims for the period of October 1, 2005 to June 30, 2006 using ICD-9 codes. In addition to hypertension and/or renal disease, other diabetes comorbid conditions and complications include myocardial infarction, coronary artery disease, cerebrovascular disease, congestive heart failure, hypercholesterolemia, peripheral vascular disease, retinopathy, chronic obstructive pulmonary disease (COPD), and sleep apnea. These clinical indicators have been included in previous studies and shown to be associated with increased morbidity and mortality for patients with diabetes.^{22,24-26} Number of chronic comorbidities was also included as a potential predictor. This variable serves as a proxy for health care utilization, and a person with higher comorbidities is more likely to visit a physician.

Statistical Analyses

In univariate analyses, the relationship between patient characteristics and high-risk groups and the relationship between patient characteristics and ACEI/ARB use were evaluated using Analysis of Variance for continuous patient characteristic variables and chi-square tests for categorical variables. To identify significant predictors of suboptimal

utilization of ACEI/ARB among high-risk diabetic patients, we used multivariate logistic regression analyses. Logistic regression models were fitted for pooled data of six states and for individual state data to explore possible regional differences across the six states. Odds ratio and 95% confidence intervals (CI) were computed for each independent variable in the multivariate regression models. All analyses were performed using the SAS statistical package version 9.1 (SAS Institute, Cary, NC).

RESULTS

Patient Characteristics

A total of 1,250,466 Medicare Part D enrollees met our inclusion criteria. Demographic and clinical characteristics of the total study population are presented in Table 1. Most of the patients were women (62.2%), with a mean age of 71.8 (± 1.9) years old. When classified according to the coexistence of hypertension and/or renal disease, 8.7% of them had both hypertension and renal disease, 90.4% had hypertension without renal disease, and 0.8% had renal involvement without hypertension. State-specific patient characteristics are presented in Table 2.

Prevalence of ACEI/ARB use

Of all high-risk patients with diabetes, 58.6% received the recommended ACEI/ARB therapy during the first 6 months of 2006. Among those who had both hypertension and renal disease, 63.1% had at least one claim for ACEI/ARB during the study period. In patients who had diabetes and hypertension but no renal involvement, the rate was 58.3%. For patients with diabetes and renal disorders without hypertension, 43.1% had filled at least one prescription for ACEI/ARB.

State-specific prevalence of ACEI/ARB use is also presented in Table 2.

Predictors of ACEI/ARB Use

Multivariate logistic regression results for pooled states data are presented in Table 3, and results of state-by-state multivariate logistic regression analyses are presented in Table 4. In multivariate analysis, compared to diabetic patients with coexisting hypertension and renal disease, ACEI/ARB use was especially low among patients with diabetes and renal disease without hypertension. After adjusting for all other characteristics studied, the estimated odds of any ACEI/ARB use for patients with diabetes and renal disease only were 50% less than those for patients who had hypertension and renal disease (OR, 0.48; 95% CI: 0.46–0.50). Female patients were more likely to receive ACEI/ARB therapy than males, and patients of black, Hispanic, or other races were more likely to use ACEI/ARB than whites. For example, blacks had 1.28 times the odds (OR, 1.28; 95% CI: 1.27–1.30) of receiving an ACEI/ARB than whites. In addition, compared to patients aged 65 and older, the odds of ACEI/ARB use were slightly lower among patients younger than 65 (OR, 0.90; 95% CI: 0.89–0.91). While the total number of chronic comorbidities was negatively associated with ACEI/ARB use (OR, 0.82; 95% CI: 0.81–0.82), compared to their counterparts, patients with individual comorbidities were more likely to have used an ACEI/ARB.

Regional Differences

Results from multivariable regression models for individual states show that the results were consistent with the pooled data. However, magnitudes of the effects were considerably

Table 1. Patient characteristics by risk group^a

Patient characteristics	Overall N=1,250,466	Hypertension and renal disease N=109,324	Hypertension only N=1,130,968	Renal disease only N=10,174
Age, year [SD] ^b	71.8 [1.9]	69.5 [12.2]	72.1 [11.6]	66.4 [14.3]
Age <65	236,378 (18.9)	29,112 (26.6)	203,623 (18.0)	3,643 (35.8)
Female	778,350 (62.2)	60,458 (55.3)	712,885 (63.0)	5,007 (49.2)
Race				
White	802,881 (64.2)	61,924 (56.6)	734,765 (65.0)	6,188 (60.8)
Black	215,567 (17.2)	23,322 (21.3)	190,488 (16.8)	1,757 (17.3)
Hispanic	105,757 (8.5)	11,313 (10.4)	93,429 (8.3)	1,015 (10.0)
Other	126,261 (10.1)	12,765 (11.7)	112,282 (9.9)	1,214 (11.9)
Medicare Part A or B				
Used any Part A	738,015 (59.2)	86,009 (78.7)	646,383 (57.2)	5,623 (55.3)
Used Part B only	501,007 (40.1)	23,197 (21.2)	473,321 (41.9)	4,489 (44.1)
Neither	11,444 (0.9)	118 (0.1)	11,264 (1.0)	62 (0.6)
Comorbidities				
Chronic obstructive pulmonary disease	332,762 (26.6)	34,242 (31.3)	296,780 (26.2)	1,740 (17.1)
Coronary artery disease	523,074 (41.8)	60,571 (55.4)	459,474 (40.6)	3,029 (29.8)
Cerebrovascular disease	252,516 (20.2)	27,351 (25.0)	204,087 (19.8)	1,078 (10.6)
Heart failure	306,050 (24.5)	45,697 (41.8)	258,212 (22.8)	2,141 (21.0)
Hypercholesterolemia	881,312 (70.5)	84,344 (77.2)	791,398 (70.0)	5,570 (54.8)
Myocardial infarction	100,957 (8.1)	15,360 (14.1)	85,059 (7.5)	538 (5.3)
Peripheral vascular disease	259,888 (20.8)	33,715 (30.8)	224,462 (19.9)	1,711 (16.8)
Retinopathy	258,028 (20.6)	37,460 (34.3)	218,264 (19.3)	2,304 (22.7)
Sleep apnea	63,682 (5.1)	8,112 (7.4)	55,246 (4.9)	324 (3.2)
Number of comorbidities [SD]	1.6 [1.4]	2.5 [1.9]	1.5 [1.6]	1.6 [1.4]

^aResults are number of patients (percentage) unless otherwise indicated; ^bchi-square tests and analysis of variance were performed to compare differences in patient characteristics across risk groups. All tests were statistically significant at $P=0.001$

Table 2. Patient characteristics and prevalence of ACEI/ARB use by state^a

Patient characteristics	Ohio	California	New York	Florida	Alabama	Mississippi
	N=152,165 ^b	N=398,202	N=258,627	N=276,897	N=91,113	N=73,462
Age, year [SD] ^c	71.3 [12.3]	72.0 [11.1]	72.6 [11.9]	72.3 [11.4]	69.9 [12.3]	69.6 [12.1]
Age <65	32,402 (21.3)	67,163 (16.9)	45,886 (17.7)	47,494 (17.2)	23,608 (25.9)	19,852 (27.0)
Female	97,549 (64.1)	237,216 (59.6)	165,091 (63.8)	170,845 (61.7)	59,331 (65.1)	48,318 (65.8)
Race						
White	126,653 (83.2)	214,974 (54.0)	163,597 (63.3)	199,039 (71.9)	60,078 (65.9)	38,540 (52.5)
Black	22,924 (15.1)	34,156 (8.6)	48,234 (18.7)	45,563 (16.5)	30,358 (33.3)	34,332 (46.7)
Hispanic	725 (0.48)	56,461 (14.2)	22,706 (8.8)	25,702 (9.3)	102 (0.1)	61 (0.1)
Other	1,863 (1.2)	92,611 (23.3)	24,090 (9.3)	6,593 (2.4)	575 (0.6)	529 (0.7)
Medicare Part A or B						
Any Part A	109,502 (72.0)	218,215 (54.8)	141,521 (54.7)	155,615 (56.2)	61,240 (67.2)	51,922 (70.7)
Part B only	41,633 (27.4)	176,128 (44.2)	114,657 (44.3)	118,799 (42.9)	28,903 (31.7)	20,887 (28.4)
Neither	1,030 (0.7)	3,859 (1.0)	2,449 (1.0)	2,483 (0.9)	970 (1.1)	653 (0.9)
Chronic obstructive pulmonary disease	50,604 (33.3)	61,706 (15.5)	77,932 (30.1)	96,574 (34.9)	26,711 (29.3)	19,235 (26.2)
Coronary artery disease	65,312 (42.9)	140,859 (35.4)	124,575 (48.2)	133,491 (48.2)	33,967 (37.3)	24,870 (33.9)
Cerebrovascular disease	36,146 (23.8)	34,505 (8.7)	66,314 (25.6)	79,768 (28.8)	20,989 (23.0)	14,794 (20.1)
Heart failure	46,701 (30.7)	59,065 (14.8)	78,413 (30.3)	75,885 (27.4)	25,630 (28.1)	20,347 (27.7)
Hypercholesterolemia	112,197 (73.7)	239,858 (60.2)	197,131 (76.2)	223,680 (80.8)	62,616 (68.7)	45,830 (62.4)
Myocardial infarction	18,524 (12.2)	19,408 (4.9)	24,003 (9.3)	26,741 (9.7)	7,020 (7.7)	5,261 (7.2)
Peripheral vascular disease	39,008 (25.6)	27,553 (6.9)	81,831 (31.6)	79,120 (28.6)	18,345 (20.1)	14,031 (19.1)
Retinopathy	32,443 (21.3)	70,873 (17.8)	67,192 (26.0)	57,973 (20.9)	15,842 (17.4)	13,705 (18.7)
Sleep apnea	10,772 (7.1)	16,837 (4.2)	9,827 (3.8)	16,800 (6.1)	5,705 (6.3)	3,741 (5.1)
Number of comorbidities [SD]	1.8 [1.7]	1.0 [1.2]	2.0 [1.8]	1.9 [1.8]	1.6 [1.6]	1.5 [1.5]
ACEI/ARB use, N (%)	87,234 (57.3)	239,719 (60.2)	151,425 (58.6)	158,072 (57.1)	51,447 (56.5)	44,736 (60.9)

^aACEI/ARB use was defined as having at least one filled prescription for an ACEI or an ARB during the study period; ^bresults are number of patients (percentage) unless otherwise indicated; ^cchi-square tests and analysis of variance were performed to compare differences in patient characteristics across states. All tests were statistically significant at $P=0.001$

different across the six states (Table 4). For instance, being black was associated with higher odds of receiving ACEI/ARB medications compared to whites in all states. However, the odds varied from 1.13 in Ohio to 1.44 in New York and California.

DISCUSSION

Despite mounting evidence that shows that ACEI/ARB therapy is effective in reducing cardiovascular and renal morbidity and mortality among high-risk diabetic patients, and despite recommendations of professional societies, the findings of this study indicate the use of recommended ACEI/ARB in actual clinical settings remains suboptimal. This trend is true across all states in the study. It should be noted that we used patient filling a prescription as a proxy for medication use in this study. Using administrative claims data, we could not determine whether the patient actually took the medication or not once it was dispensed; nonetheless, previous research has shown that filling a prescription is usually consistent with taking the drug.²⁷ Among Medicare Part D enrollees with diabetes and concomitant hypertension and/or renal disease, we found that only about 60% of patients were receiving indicated ACEI/ARB therapy, ranging from 56.5% in Alabama to 60.9% in Mississippi. This underuse may be due to physicians failing to prescribe an ACEI/ARB, patients failing to fill the prescription, or both. Educational efforts should be directed at physicians to promote the practice of evidence-based medicine as well as to patients to improve ACEI/ARB use among high-risk patients with diabetes. It should be noted that our study measured ACEI/ARB use during the first 6

Table 3. Associations between patient characteristics and ACEI/ARB use for pooled data^a

Patient characteristics	Pooled data
	OR ^b (95% CI)
ACEI/ARB use, N (%)	732,633 (58.6)
Risk group	
Hypertension only	0.83 (0.82–0.84)
Renal disease only	0.48 (0.46–0.50)
Hypertension and renal disease	1.00
Medicare Part A or B	
Used any Part A	1.00
Used Part B only	0.76 (0.76–0.77)
Neither	1.17 (1.12–1.21)
Age <65 ^c	0.90 (0.89–0.91)
Female ^d	1.10 (1.10–1.11)
Race	
White	1.00
Black	1.28 (1.27–1.30)
Hispanic	1.36 (1.34–1.38)
Other	1.29 (1.27–1.31)
Chronic obstructive pulmonary disease ^e	1.05 (1.04–1.06)
Coronary artery disease ^e	1.07 (1.06–1.08)
Cerebrovascular disease ^e	1.19 (1.17–1.20)
Heart failure ^e	1.36 (1.35–1.38)
Hypercholesterolemia ^e	1.42 (1.41–1.44)
Myocardial infarction ^e	1.28 (1.26–1.30)
Peripheral vascular disease ^e	1.20 (1.19–1.21)
Retinopathy ^e	1.19 (1.17–1.20)
Sleep apnea ^e	1.12 (1.10–1.14)
Number of comorbidities	0.82 (0.81–0.82)

^aACEI/ARB use was defined as having at least one filled prescription for an ACEI or an ARB during the study period; ^bodds ratios from multivariate analyses, each variable in model was adjusted for all other variables in table;

^creference group: age ≥ 65 ; ^dreference group: male gender; ^ereference group: absence of the condition

Table 4. Associations between patient characteristics and ACEI/ARB use by state^a

Patient characteristics	Ohio	California	New York	Florida	Alabama	Mississippi
	OR ^b	OR	OR	OR	OR	OR
	(95% CI)	(95% CI)	(95% CI)	(95% CI)	(95% CI)	(95% CI)
Risk group						
Hypertension only	0.80 (0.79–0.82)	0.89 (0.86–0.91)	0.89 (0.86–0.91)	0.76 (0.73–0.78)	0.89 (0.85–0.94)	0.93 (0.87–0.99)
Renal disease only	0.45 (0.42–0.49)	0.50 (0.46–0.56)	0.50 (0.46–0.56)	0.47 (0.42–0.51)	0.50 (0.42–0.60)	0.49 (0.40–0.61)
Hypertension and renal	1.00	1.00	1.00	1.00	1.00	1.00
Medicare Part A or B						
Any Part A	1.00	1.00	1.00	1.00	1.00	1.00
Part B only	0.69 (0.68–0.70)	0.69 (0.68–0.70)	0.69 (0.68–0.70)	0.82 (0.81–0.84)	0.86 (0.84–0.89)	0.88 (0.85–0.91)
Neither	1.00 ^c (0.92–1.10)	1.25 (1.15–1.36)	1.25 (1.15–1.36)	1.29 (1.19–1.40)	1.24 (1.08–1.41)	1.05 ^c (0.89–1.23)
Age <65 ^d	0.86 (0.84–0.87)	0.91 (0.89–0.93)	0.91 (0.89–0.93)	0.90 (0.88–0.92)	0.93 (0.90–0.96)	0.96 (0.92–0.99)
Female ^e	0.86 (0.84–0.87)	1.06 (1.05–1.08)	1.06 (1.05–1.08)	1.08 (1.07–1.10)	1.15 (1.11–1.18)	1.16 (1.13–1.20)
Race						
White	1.00	1.00	1.00	1.00	1.00	1.00
Black	1.13 (1.10–1.16)	1.44 (1.41–1.47)	1.44 (1.41–1.47)	1.33 (1.30–1.36)	1.15 (1.12–1.18)	1.31 (1.27–1.35)
Hispanic	1.22 (1.20–1.25)	1.66 (1.62–1.71)	1.66 (1.62–1.71)	1.38 (1.34–1.41)	1.12 ^c (0.75–1.66)	0.73 ^c (0.44–1.22)
Other	1.22 (1.20–1.24)	1.54 (1.50–1.58)	1.56 (1.49–1.58)	1.24 (1.18–1.30)	1.00 ^c (0.85–1.18)	1.10 ^c (0.92–1.31)
Chronic obstructive pulmonary disease ^f	1.10 (1.08–1.13)	1.08 (1.06–1.10)	1.08 (1.06–1.10)	1.01 ^c (0.99–1.03)	1.01 ^c (0.97–1.05)	1.07 (1.03–1.12)
Coronary artery disease ^f	1.12 (1.10–1.13)	1.12 (1.10–1.14)	1.12 (1.10–1.14)	1.05 (1.03–1.07)	1.02 ^c (0.98–1.05)	0.99 ^c (0.96–1.03)
Cerebrovascular disease ^f	1.22 (1.19–1.26)	1.18 (1.15–1.21)	1.18 (1.15–1.21)	1.16 (1.14–1.20)	1.21 (1.16–1.26)	1.23 (1.1–1.29)
Heart failure ^f	1.40 (1.36–1.44)	1.37 (1.34–1.41)	1.37 (1.34–1.41)	1.34 (1.31–1.37)	1.37 (1.31–1.43)	1.40 (1.34–1.46)
Hypercholesterolemia ^f	1.44 (1.41–1.46)	1.45 (1.42–1.49)	1.45 (1.42–1.48)	1.41 (1.38–1.43)	1.42 (1.38–1.46)	1.41 (1.37–1.46)
Myocardial infarction ^f	1.33 (1.29–1.38)	1.32 (1.28–1.36)	1.32 (1.28–1.36)	1.24 (1.20–1.28)	1.26 (1.19–1.33)	1.37 (1.29–1.47)
Peripheral vascular disease ^f	1.27 (1.23–1.31)	1.21 (1.19–1.24)	1.21 (1.19–1.24)	1.20 (1.18–1.23)	1.10 (1.05–1.15)	1.12 (1.07–1.17)
Retinopathy ^f	1.20 (1.18–1.22)	1.22 (1.20–1.25)	1.22 (1.20–1.25)	1.14 (1.11–1.16)	1.19 (1.15–1.23)	1.17 (1.13–1.22)
Sleep apnea ^f	1.05 (1.01–1.08)	1.25 (1.20–1.31)	1.25 (1.20–1.31)	1.16 (1.12–1.20)	1.42 (1.38–1.46)	1.14 (1.06–1.23)
Number of comorbidities	0.79 (0.78–0.79)	0.81 (0.80–0.82)	0.81 (0.80–0.82)	0.84 (0.83–0.85)	0.82 (0.80–0.83)	0.79 (0.78–0.81)

^aACEI/ARB use was defined as having at least one filled prescription for an ACEI or an ARB during the study period; ^bodds ratios from multivariate analyses, each variable in model was adjusted for all other variables in table; ^codds ratios non-significant at $P=0.05$ level; ^dreference group: age ≥ 65 ;

^ereference group: male gender;

^freference group: absence of the condition

months of 2006, which was the uptake period of Medicare Part D. Enrolling with or switching to Part D may have confounded our measure of ACEI/ARB use. In addition, as patients might have medications carried over from their previous prescription drug plans, the actual use of ACEI/ARB might have been underestimated. In addition, the Medicare prescription drug coverage gap (also known as the “donut hole”) may also impact the utilization of ACEI/ARB among high-risk diabetes patients. Future studies evaluating ACEI/ARB use in the Medicare population should employ a different time frame, compare patient health outcomes associated with ACEI/ARB use, and also examine the effect of the “donut hole” on medication use among patients with diabetes.

The percentage of patients receiving ACEI/ARB therapy in this study was comparable to the rates reported in the literature assessing the utilization of ACEI/ARB using claims data.^{16–18,23} A study of low-income elderly Medicare beneficiaries in Pennsylvania found that 50.7% of the patients with diabetes and comorbid hypertension and/or renal disease were receiving ACEI/ARB therapy during the first 3 months of 2003,²³ whereas two studies with a 1-year observation period reported the rates of high-risk patients receiving ACEI/ARB therapy were 61% and 72.6%, respectively.^{16,17} It should be noted that the outcome of interest in all of these studies was any use of ACEI/ARB, defined as at least one filled prescription of ACEI/ARB during the study period. Therefore, more patients would be “captured” as ACEI/ARB users with a longer

study period. Previous research, however, has either employed a small sample,¹⁸ included patients from a restricted geographic location,^{16,17,23} or examined patients of certain age groups only,^{16,23} limiting the generalizability of the observed results. In the current study, we employed a large population of high-risk diabetes patients, and we also explored regional differences in ACEI/ARB use in routine care settings.

In this study, we also identified several patient characteristics that can predict suboptimal ACEI/ARB utilization. Although the magnitude of individual variables’ effect vary considerably across the six states, results from all six states are consistent and share the same direction with results from the pooled data. All of these variables are available to physicians when they make clinical decisions. To realize the therapeutic benefits of ACEI/ARB medications in preventing diabetes-related complications, physicians should be aware of the predictors of ACEI/ARB underuse among patients with diabetes and comorbid hypertension and/or renal disease, and to improve the prescribing rate of ACEI/ARB medications to these high-risk diabetic patients. For example, we found that after adjusting for all other covariates, compared with patients over the age of 65, those younger than 65 years old were less likely to have received ACEI/ARB treatment, which is consistent with previous studies reporting an association between age and quality of diabetes care.^{28,29}

Our study found that patients of non-white races were significantly more likely to have received ACEI/ARB treatment

across all states. In general, blacks were 28% more likely than whites to have received ACEI/ARB therapy, ranging from 13% more in Ohio to 44% more in California and New York. Although ACEI/ARB might not be the most preferred choice of antihypertensives for black patients, clinical practice guidelines still recommend ACEI/ARB use in black patients with hypertension because of their effectiveness in reducing diabetes' macro- and micro-vascular complications.⁷⁻⁹ This finding is encouraging and consistent with previous reports showing that black patients with diabetes and hypertension were more likely to receive a more intensive antihypertensive regimen including an ACEI or an ARB to achieve the same level of blood pressure control as in whites.³⁰

Patients with comorbidities like hypercholesterolemia, heart failure, and myocardial infarction were more likely to be prescribed with ACEI/ARB therapy than their counterparts, suggesting that individual comorbidities may trigger physicians' treatment decisions toward prescribing ACEI/ARB. However, as the number to chronic comorbidities increases, the likelihood of physicians prescribing ACEI/ARB to high-risk diabetes patients decreases. It is worth noticing that in patients with COPD, ACEI/ARB medications were also more likely to be prescribed. Research has shown that certain people using ACEIs develop severe coughs leading to discontinuation of therapy. ARBs also induce cough, but to a lesser extent.³¹ Despite such evidence, high-risk diabetes patients with already impaired pulmonary function were found to be more likely to use ACEI/ARB; this is probably because the significant benefits associated with using these medications outweigh the risks of side effects.

LIMITATIONS

This study has several limitations. First, there are many factors that can potentially cause underutilization of pharmacological therapies among patients with diabetes, both from the physician side and from the patient side. Use of administrative claims data limits the ability to characterize some of the factors because they were not available in the dataset. Second, our study sample consisted of a relatively large population of Medicare Part D enrollees with diabetes. On one hand, our study demonstrates that underutilization of ACEI/ARB among high-risk diabetic patients is highly prevalent, and therefore, it is a serious public health problem and may be a key factor underlying the suboptimal quality of care and rising costs in the current health care system. On the other hand, the predicting effect of various factors may have been amplified by the sample size. Caution should be exercised when interpreting the results from this study.

CONCLUSION

This study provides evidence that ACEI/ARBs are underutilized among high-risk patients with diabetes enrolled in Medicare Part D; we found that less than 60% of high-risk diabetes patients received the recommended ACEI/ARB therapy. Several patient demographic and clinical characteristics, which are all available to clinicians at initiation of treatment, are associated with suboptimal ACEI/ARB use. Physicians should be aware of the significant predictors of suboptimal

ACEI/ARB use, and efforts should be made to improve the utilization of ACEI/ARB among diabetic patients with concomitant hypertension and/or renal disease.

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