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Relationships Between Medication Adherence and Cardiovascular Disease Risk Factor Control in Elderly Patients With Diabetes

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Abstract

Background—The Centers for Medicare and Medicaid Services (CMS) Medicare Star program provides incentives to health plans when their patients with diabetes meet adherence targets to angiotensin-converting enzyme inhibitors/angiotensin receptor blockers (ACEI/ARB) and statins. While a link between adherence and cardiovascular risk factor control is established, most studies included young patients with few comorbidities. Whether the Star adherence target is associated with reduced blood pressure or low-density lipoprotein cholesterol (LDL-C) in complex older patients is not well understood.

Objectives—Determine correlates of adherence and examine the effect of meeting Star adherence targets on blood pressure and LDL-C in the Medicare-aged diabetes population.

Design and Subjects—Retrospective cohort study of 129,040 patients with diabetes aged 65 or older.

Measures—Adherence estimated using proportion of days covered target 0.8; blood pressure < 140/90 mg Hg; LDL-C < 100 mg/dL. Modified Poisson regression used to assess relationships.

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Presentations

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Conflicts of Interest:

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Results—Adherence differed little across elderly age groups. Compared to no comorbidity, high comorbidity (4) was associated with lower ACEI/ARB (RR 0.88 [95%CI 0.87, 0.89]) or statin (RR 0.91 [0.90, 0.92]) adherence. ACEI/ARB adherence was not associated with blood pressure < 140/90 mm Hg in patients ≥ 85 years (RR 1.01 [0.96, 1.07]) or with multiple comorbidities (e.g., 3: RR 1.04 [0.99, 1.08]). Statin adherence and LDL-C < 100 mg/dL were associated in all elderly age groups (e.g., ≥ 85: RR 1.13 [1.09, 1.16]) and comorbidity levels (e.g., 4: RR 1.13 [1.12, 1.15]).

Conclusions—Adherence to ACEI/ARB is not linked with reduced blood pressure in patients with diabetes who are at least 85 years or with multiple comorbidities.

Keywords

elderly; hypertension; hyperlipidemia; medication adherence; Medicare Star; angiotensin converting enzyme inhibitor; angiotensin receptor blocker; statin

Adherence to cardiovascular medications such as antihypertensives and antihyperlipidemics is associated with reduced cardiovascular disease (CVD) morbidity and mortality.^{1–4} However, studies of the relationships between medication adherence and CVD risk have often been in adult populations that excluded elderly individuals, included relatively few elderly overall, or included few elderly patients with diabetes.^{1,4–7} Whether good medication adherence is associated with improved risk factor control in older patients with diabetes is largely unknown. Similarly, clinical trials testing the efficacy of lipid and blood pressure (BP) medications often excluded patients with severe or symptomatic comorbidities.^{8,9} Yet, accounting for comorbidity, particularly among patients with diabetes, is important in that up to 40% of patients with diabetes have multiple comorbidities.^{10,11} Experts have called for studies using large observational data sets to enhance understanding of treatment effects in patients who are older and who have comorbid conditions.^{8,12}

Despite gaps in knowledge about relationships between medication adherence and surrogate CVD outcomes such as BP and lipid control in elderly Medicare-aged patients, the Centers for Medicaid and Medicare Services (CMS) uses an adherence metric within its quality of care measures for the Medicare Star program.^{13,14} The Medicare Star program gives an overall rating of the health plan's quality and performance for the types of services the plan offers.¹⁵ CMS attaches monetary incentives to each health plan's performance on Star measures. Components of the Star measures include adherence to oral antihypertensives, specifically angiotensin-converting enzyme inhibitors (ACEI) and angiotensin receptor blockers (ARB), and adherence to oral antihyperlipidemics, specifically statins. The Star adherence metric employs the proportion of days covered (PDC) as a proxy for medication adherence, considering a PDC ≥ 0.8 (i.e., possession of the medication at least 80% of the days in the measurement period) as "target adherence." This target adherence metric is applied uniformly across the Medicare population, with no upper age limit and no adjustment for comorbid conditions.

High performance on quality metrics such as the Star adherence metric should positively correlate with improved clinical and surrogate outcomes, yet there is scant evidence on whether achieving the Star adherence target directly correlates with reduced BP or lipids

among the elderly. To begin to address this knowledge gap, we sought to clarify the links between ACEI/ARB and statin adherence, as measured by the Star metric, and BP or lipid values in a large, geographically and demographically diverse Medicare-aged population with diabetes. The purpose of this study was to assess the relationships between elderly age and comorbidity burden on ACEI/ARB or statin adherence, and to examine the relationship between target ACEI/ARB or statin adherence and levels of BP and lipids in a large sample of patients with diabetes representative of the diabetic population included in Medicare Star quality measures.

Methods

Setting and Population

This retrospective cohort study was conducted at three Kaiser Permanente (KP) regions (Colorado [KPCO], Northwest [KPNW], and Northern California [KPNC]) in the United States. KP is a not-for-profit integrated group-model healthcare delivery system that, at the time of this study, served 4.1 million members across these three regions. This KP member population includes Medicaid and Medicare enrollees, with Medicare enrollees participating in Medicare Advantage plans. KP regions operate their own outpatient medical office facilities that also offer integrated pharmacy, radiology, and laboratory services. Over 95% of older KP members have pharmacy benefits and obtain their prescription medications from KP pharmacies.

This study included patients with diabetes in the SURveillance PREvention and ManagEment of Diabetes Mellitus (SUPREME-DM) registry, the largest civilian diabetes registry in the United States.^{16–20} The SUPREME-DM registry, known as the DataLink, is a standardized, distributed data infrastructure that leverages electronic health record (EHR) and other clinical and administrative databases from 11 Health Care Systems Research Network (HCSRN, formerly the HMORN) member organizations.²¹ The DataLink includes a defined population of over 1.2 million adults with diabetes (from 2005 forward), identified using combinations of coded diagnoses, medications, and laboratory test results. Patients with all types of diabetes (type 1, type 2, and other less common types) are represented in the DataLink, as are both incident and prevalent cases. The DataLink's primary data source is the HCSRN Virtual Data Warehouse (VDW);²² exposure, adherence outcome, and covariate data variables were obtained from the Datalink and VDW at each site. For this study, we included DataLink patients aged 65 or older in 2010 from the participating KP regions (n=129,040).²³

The KPNC Institutional Review Board (IRB) approved this study and waived the informed consent requirement. KPCO and KPNW ceded IRB oversight to the KPNC IRB.

Exposures and Outcomes

To determine relationships between age and ACEI/ARB or statin adherence and between comorbidities and ACEI/ARB or statin adherence, age and comorbidity were considered the exposures of interest and adherence was considered the outcome of interest. In examining the effect of ACEI/ARB or statin adherence on cardiovascular risk factor values, adherence

was considered the exposure of interest and systolic and diastolic BP values or low-density lipoprotein (LDL-C) values were considered the outcomes of interest. To align with the timeframe of the Medicare Star quality of care measures, the period of measurement for exposures and outcomes was a calendar year.

The ACEI/ARB and statin single-ingredient and combination products included were those listed in the Star technical specifications.^{13,24,25} The PDC for each person for each therapeutic category was estimated from pharmacy dispensing records, using the days' supply of medication dispensed with each dispensing and the number of dispensings over the measurement period.²⁶ In the Star metric, the measurement period is the date of the first dispensing within a calendar year through the last day of that year the patient has the medication of interest in their possession. For this study, to align with the Star metric, each patient's PDC was dichotomized into target adherence (PDC $\geq$ 0.8) or not (PDC < 0.8), and required patients to have a minimum of two dispensings in the year to be included in the PDC denominator. We had previously calculated the PDC for each patient in our patient sample: ²³ 86,210 patients had $\geq$ 2 ACEI/ARB dispensings in 2010, including 69,402 (81%) with target adherence; 93,276 had $\geq$ 2 statin dispensings, including 73,582 (79%) who met the adherence target.²³

Patient age was determined as of January 1, 2010. Comorbidity burden was determined using ICD-9 coded diagnoses/procedures by counting the number of unique conditions diagnosed in 2009; each condition was counted once. These 19 conditions were included in statin analyses: atrial fibrillation, alcohol abuse, Alzheimer's, anxiety, arthritis, asthma, cancer, chronic kidney disease (CKD), chronic obstructive pulmonary disease, dementia, depression, complicated diabetes (diabetes without complications was not included because it was present in all study patients), drug abuse, heart failure, ischemic heart disease, osteoporosis, retinopathy, stroke, and visual impairment.^{27,28} For ACEI/ARB analyses, the same conditions were included as for statin analysis with the exceptions of complicated diabetes or CKD because these conditions can be the indication for ACEI/ARB use rather than comorbid conditions.

Systolic and diastolic BP and LDL-C values were determined from each patient's EHR. LDL-C and BP control were defined using standards applicable in 2010: BP < 140/90 mm Hg or < 130/80 mm Hg;²⁹ LDL-C < 100 mg/dL.³⁰ It was determined whether each patient achieved these BP or LDL-C values using the last measurement in 2010.

Covariates

Covariates of interest were identified based on prior literature.^{23,31,32} Demographic, enrollment, and clinical covariates included gender, race/ethnicity, whether the patient was enrolled in the health plan the full calendar year, KP region, and body mass index (BMI; kg/m²). Socioeconomic variables included income and education (determined from the geocoded census block group). Medication covariates included medication burden (the number of unique medication classes the patient was taking at the start of 2010), ACEI/ARB or statins mean days' supply in 2010, and percentage of ACEI/ARB or statin refilled in 2010 through a mail order pharmacy. Benefit structure variables included prescription co-payment for a 30-day supply of a generic medication and annual individual out-of-pocket maximum

in 2010. Use of high intensity ACEI/ARB or statin treatment also was included in the BP and LDL-C analyses. High intensity BP treatment was defined as being dispensed 3 antihypertensive classes concomitantly. High intensity hyperlipidemia treatment was defined as taking atorvastatin 40 – 80 mg or rosuvastatin 20 – 40 mg daily.

Statistical Analysis

Working hypotheses for this study were 1) that very elderly (age 85) patients with diabetes are less likely to achieve ACEI/ARB or statin target adherence than younger elderly and that patients with multiple comorbid conditions are less likely to achieve target adherence than patients with no or few comorbidities, and 2) achieving ACEI/ARB or statins target adherence in very elderly patients or in patients with multiple comorbid conditions is not associated with BP or lipid control.

To test these hypotheses and to examine whether differences in outcomes varied by selected patient characteristics, a modified Poisson regression approach with robust error variances was used to obtain estimated risk ratios (RR) and 95% confidence intervals (95%CI). This approach has been recommended in studies where the outcome of interest is common.³³

Our ACEI/ARB adherence model (outcome) included age and comorbidities (exposures), as well as all covariates listed previously.^{23,31,32} Similar models were fit to examine relationships between statin adherence (outcome) and age and comorbidities (exposures).

To analyze the impact of meeting the ACEI/ARB and statin adherence target (exposure) on BP and LDL-C control (outcomes), a modified Poisson regression modeling technique was used similar to that outlined above. Two BP control definitions were assessed in separate models (BP < 140/90 mm Hg and < 130/80 mm Hg). One LDL-C control definition was assessed (LDL-C < 100 mg/dL). Covariates for the BP and LDL-C control models included age, number of comorbidities, and all covariates listed previously.

All p values are two-sided; $p < 0.05$ and 95%CI that did not include 1 were considered statistically significant. All analyses were conducted in Stata/SE 12.1 (StataCorp LP, College Station, Texas).

Results

Demographic and clinical characteristics of the full cohort ($n=129,040$) and of the cohort subsets with 2 ACEI/ARB ($n=86,210$) or statin ($n=93,276$) dispensings are shown in Table 1. BP measurements were available for 98% ($n=84,220$) of those with 2 ACEI/ARB dispensings. Based on the last measurement in 2010, 83% ($n=70,242$) achieved BP < 140/90 mm Hg and 62% ($n=52,290$) achieved BP < 130/80 mm Hg. LDL-C measurements were available for 95% ($n=88,159$) of those with 2 statin dispensings. Of these patients, 89% ($n=78,398$) achieved LDL-C < 100 mg/dL based on the last value in 2010.

Adherence and Age or Comorbidity

Table 2 presents results of analyses of the probability of being adherent. The likelihood of being adherent to ACEI/ARB was similar across all elderly age groups. Increasing

comorbidity was associated with decreasing likelihood of ACEI/ARB adherence (1 comorbidity: RR 0.97 [95%CI 0.97, 0.98], 4: RR 0.88 [0.87, 0.89] vs. no).

The probability of being adherent to statins differed modestly across age groups (70 – 74 years: RR 1.01 [1.00, 1.02], 75 – 79, 80 – 84, and 85: all RR 1.02 [1.01, 1.03] vs. 65 – 69) (Table 2). Increasing comorbidity was associated with decreasing likelihood of statin adherence (1 comorbidity: RR 0.97 [0.96, 0.99], 4: RR 0.91 [0.90, 0.92] vs. no).

Table 2 also displays estimates of the associations between other measured characteristics and adherence. All associations were modest, with the exception of days' supply dispensed. Compared to dispensing less than 31 days' supply of either ACEI/ARB or statin, greater days' supply was progressively associated with higher adherence (ACEI/ARB: 31 – 60 days RR 1.13 [1.09, 1.18], 61 – 90: RR 1.35 [1.31, 1.39], > 90: RR 1.60 [1.54, 1.65]; statin, 31 – 60 days: RR 1.13 [1.09, 1.17], 61 – 90: RR 1.46 [1.42, 1.51], > 90: RR 1.60 [1.55, 1.65]).

Cardiovascular Risk and Age or Comorbidity

Relationships among BP < 140/90 mm Hg, age, and target ACEI/ARB adherence, and among LDL-C < 100 mg/dL, age, and target statin adherence are shown in Figures 1A and 2. While there was a small positive relationship between BP < 140/90 mm Hg and target ACEI/ARB adherence for selected ages (65 – 69 years: RR 1.04 [1.02, 1.06], 70 – 74: RR 1.03 [1.01, 1.05]; 80 – 84: RR 1.04 [1.01, 1.07]), there was no association for others, including the oldest age group (75 – 79 years: RR 1.01 [0.98, 1.03], 85: RR 1.01 [0.96, 1.07]) (Figure 1A). RR estimates for relationships between BP < 130/80 mm Hg and target ACEI/ARB adherence for all age groups show slightly stronger associations (Figure 1B), however review of the 95%CI for the BP < 130/80 mm Hg findings for all age groups yielded the same interpretations as with BP < 140/90 mm Hg (Figure 1A).

Positive, statistically significant relationships were observed between targeted statin adherence and LDL-C < 100 mg/dL in all age groups (Figure 2A). Estimated risk ratios were similar across age groups (65 – 69 years: RR 1.14 [1.12, 1.16], 70 – 74: RR 1.16 [1.14, 1.18], 75 – 79: RR 1.15 [1.13, 1.18], 80 – 84: 1.16 [1.13, 1.19], 85: RR 1.13 [1.09, 1.16]).

Associations between BP < 140/90 mm Hg and target ACEI/ARB adherence were similar across patients with no to multiple comorbidities; all relationships were modest and some were not statistically significant (no comorbidity: RR 1.03 [1.01, 1.04], 1: RR 1.03 [1.01, 1.05], 2: RR 1.03 [1.01, 1.06], 3: RR to 1.04 [0.99, 1.08], 4: RR 1.06 [1.01, 1.11])(Figure 1C). When BP < 130/80 mm Hg was evaluated, a modest positive relationship was observed between BP, ACEI/ARB adherence and number of comorbidities only in patients with no or one comorbidity (no comorbidity: RR 1.04 [1.01, 1.08], 1: RR 1.06 [1.02, 1.10], 2: RR 1.02 [0.98, 1.07], 3: RR 1.06 [0.99, 1.14], 4 RR 1.02 [0.94, 1.11])(Figure 1D).

Positive associations were observed between LDL-C < 100 mg/dL, comorbidities, and target statin adherence. The RR were similar across patients with 0, 1, 2, 3, and 4 comorbid conditions (no comorbidity: RR 1.19 [1.16, 1.21], 1: RR 1.15 [1.13, 1.18], 2: RR 1.16 [1.14, 1.18], 3: RR 1.13 [1.11, 1.15], 4: RR 1.13 [1.12, 1.15])(Figure 2B).

Discussion

In this large cohort of patients with diabetes, we found little difference in adherence to ACEI/ARB or statins across age groups 65 years through 85 years. Patients with multiple comorbid conditions were less likely to be adherent to ACEI/ARB or statins than those with no or few comorbidities. Importantly, in this Medicare-aged cohort, achieving target ACEI/ARB adherence was not associated with BP control in the oldest patients (85 years and older) whether control was defined as $< 140/90$ mm Hg or $< 130/90$ mm Hg. A modest positive relationship between BP control and ACEI/ARB adherence in patients with some levels of comorbidity was observed when control was defined as $< 140/90$ mm Hg. However, when control was defined as $< 130/80$ mm Hg, the relationship between BP and ACEI/ARB adherence remained only for patients with low or no comorbidity. In contrast, achieving targeted statin adherence was associated with LDL-C control across all elderly age groups and all levels of comorbidity.

Clinicians, patients, and policy-makers have highlighted the need for quality metrics for the elderly that are patient-centric and correlate with outcomes, and for high-quality comparative effectiveness research to improve care for patients with multiple chronic conditions.¹² This current retrospective observational study provides evidence that ACEI/ARB adherence is not associated with BP control either in the oldest patients or in those with multiple chronic conditions, raising a question about the relevancy of the Medicare Star ACEI/ARB adherence metric for this subset of patients with diabetes. However, evidence from prospective randomized trials is needed to conclusively answer this question.

Many studies of patient-level correlates of medication adherence suggest that older patients have higher adherence than younger patients, but our findings do not support differences in adherence among elderly patients with diabetes who have a high chronic disease burden that are taking either ACEI/ARB or statins. Most of the studies that found older patients had higher adherence did not focus on the elderly,^{34–36} did not fully examine age groups older than 65,³⁷ and/or did not study Medicare-based samples.^{34–38} The few studies that have closely examined adherence to CVD medications in the elderly and very elderly suggest progressively older age may be associated with lower adherence.^{39,40} Our findings, which control for comorbidity burden and multiple covariates, do not agree with these previous studies.

Lipid and BP control among patients with diabetes reduces CVD and mortality risk.^{41,42} Simultaneous control of both risk factors is especially protective against adverse CVD outcomes,^{43,44} with effects lasting beyond intensive intervention.⁴⁵ Previous studies suggest that higher adherence to CVD medications in diabetes patients is associated with improved risk factor control, lower hospitalization rates, and reduced mortality.^{2,34–36} However, most of those studies differed from our current work in that they did not focus on elderly patients, did not fully account for comorbidities, studied non-representative samples, or used non-standard adherence definitions.^{46,47} These differences in study design and populations between previous studies and the current study potentially contribute to the different results

that were observed (i.e., no association between BP control and targeted ACEI/ARB adherence in the oldest patients or in those with high comorbidity).

Multiple age-related physiologic factors potentially contribute to why the very elderly could achieve target adherence and yet have uncontrolled BP. Some of these factors include, for example, decreased baroreceptor sensitivity and the fact that ACEI/ARB (as well as other currently available antihypertensive agents) do not specifically target vascular stiffness.

In 2010, hypertension treatment goals for patients with diabetes reflected the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure²⁹ and the results of the Action to Control Cardiovascular Risk in Diabetes (ACCORD) study, a study that did not demonstrate benefit for achieving a systolic BP of 120 versus 140 mm Hg.⁴⁸ Further, clinicians then (and now) approached treating hypertension in the very elderly much more cautiously than in younger patients, in large part due to concerns about risks of adverse events such as hypotension, falls, and syncope. Publication of the Systolic Blood Pressure Intervention Trial (SPRINT) in 2015 altered hypertension treatment goals for patients at high risk for cardiovascular events, including elderly patients (28% of patients enrolled in SPRINT were 75 years of age).⁴⁹ SPRINT demonstrated that targeting a systolic BP < 120 mm Hg (versus < 140 mm Hg) resulted in lower rates of cardiovascular events and death. However, applicability of SPRINT results to patients with diabetes remains unclear as diabetes patients were excluded from SPRINT. Also concerning is that higher rates of hypotension, syncope, electrolyte abnormalities and acute kidney dysfunction were observed in the SPRINT group that had a systolic BP < 120 mm Hg.

Strengths of this study include the large number of patients in the PDC calculation and the very high percentages of patients with available BP and LDL-C measurements. The PDC for both the ACEI/ARB and statin users was at targeted adherence (0.8) for a large percentage of the cohort. This high percentage of patients with targeted adherence was anticipated because KP regions are consistently among the highest ranking health plans in the Medicare Star quality of care ratings and the Medicare Star adherence metric excludes the most non-adherent patients.³²

The PDC had several limitations. First, it is not a direct measurement of adherence; rather it is a surrogate marker that assumes the patient ingested the medication if the prescription was dispensed. Second, the 0.8 PDC cut-point is not clearly established as optimal for effectiveness or safety in elderly patients with diabetes.^{26,50} Yet, because the Star metric employs the 0.8 target, it was crucial to study the relationships between this cut-point and CVD risk factor control.

Other limitations include that, as with any observational study, selection bias is a concern. It is possible that patients with higher adherence differ from patients with lower adherence in ways that are difficult to measure, or that there are unobserved factors that could affect patient outcomes. There could be other benefits (beyond BP and LDL-C) to being adherent with ACEI/ARB or statins; this study was not designed to assess other benefits. Outcome values for BP and LDL-C were determined using the last measurement available in the year;

a minimum number of readings during study follow-up were not required. Patients could have had different values within the year (or median values that differed from the last measurement). It is also possible that this population of Medicare Advantage patients differs from, for example, Medicare fee-for-service patients. However, because these adherence and outcomes questions are unlikely to be studied through randomized trials because of cost, comparative effectiveness methods were used to estimate relationships between ACEI/ARB or statin adherence and CVD risk factor control while minimizing bias, given the measured differences.

In conclusion, no link was found between adherence to ACEI/ARB and BP control among diabetes patients who are very elderly or who have multiple comorbidities. This is the first evidence to question this Medicare Star adherence quality of care metric in the oldest diabetes patients and in those with multiple comorbid conditions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Figure 1A

Figure 1B

Figure 1C

Figure 1D

Figure 1.

Associations of meeting the Medicare Star ACEI/ARB adherence target with BP control and age or comorbidity among elderly patients with diabetes. Estimates were from modified Poisson regressions using blood pressure control < 140/90 mm Hg (Panels A and C) or < 130/80 mm Hg (Panels B and D) at the last recorded measurement in 2010 as the dependent variable, and adherence PDC ≥ 80% compared with PDC < 80% as the main independent variable. Regression models controlled for age (comorbidity models), number of comorbidities (age models), gender, race/ethnicity, medication burden, length of enrollment in the health plan during 2010, mean days' supply of ACEI/ARBs, intensity of treatment,

and an interaction term for meeting the adherence target and taking high intensity treatment. Panel 1A: age and BP < 140/90 mm Hg; Panel 1B: age and BP < 130/80 mm Hg; Panel 1C: comorbidity and BP < 140/90 mm Hg; Panel 1D: comorbidity and BP < 130/80 mm Hg. ACEI/ARB=angiotensin converting enzyme inhibitor/angiotensin receptor blocker; BP=blood pressure; PDC=proportion of days covered.

Figure 2A

Figure 2B

Figure 2.

Associations of meeting the Medicare Star statin adherence target with LCL-C < 100 mg/dL and age or comorbidity among elderly patients with diabetes. Estimates were from modified Poisson regressions using LDL-C < 100 mg/dL at the last recorded measurement in 2010 as the dependent variable, and statin adherence PDC ≥ 80% compared with PDC < 80% as the main independent variable. Regression models controlled for age (comorbidity model), comorbidity (age model), gender, race/ethnicity, medication burden, length of enrollment in the health plan during 2010, mean days' supply of statins, intensity of treatment, and an

interaction term for meeting the adherence target and taking high intensity treatment. Panel 2A: age and LDL-C < 100 mg/dL; Panel 2B: comorbidity and LDL-C < 100 mg/dL. LCL-C=low-density lipoprotein cholesterol; PDC=proportion of days covered.

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Table 1

Characteristics of the Study Cohort of Elderly Patients With Diabetes

Characteristic	All patients, n=129,040 (%)	Patients with 2 dispensings of an ACEI/ARB, n=86,120 (%)	Patients with 2 dispensings of a statin, n=93,276 (%)
Age group (years)			
65 – 69	38,298 (30)	26,984 (31)	28,625 (31)
70 – 74	32,823 (25)	23,006 (27)	24,874 (26)
75 – 79	26,475 (21)	17,803 (21)	19,461 (21)
80 – 84	18,442 (14)	11,514 (13)	12,759 (14)
85	13,002 (10)	6813 (8)	7557 (8)
Female	63,689 (49)	42,712 (50)	45,292 (49)
Race/ethnicity ^a			
White	75,880 (59)	50,648 (59)	55,407 (59)
Asian	13,306 (10)	8797 (10)	9779 (10)
Black	10,063 (8)	6570 (8)	6823 (7)
Native Hawaiian/Pacific Islander	633 (<1)	411 (<1)	462 (1)
American Indian/Alaskan Native	444 (<1)	283 (<1)	303 (<1)
Hispanic	16,492 (13)	11,020 (13)	11,747 (13)
Body mass index (kg/m ²) ^a			
< 18	944 (1)	400 (<1)	437 (<1)
18 – 24.9	23,854 (18)	14,061 (16)	16,003 (17)
25 – 29.9	42,673 (33)	28,525 (33)	31,549 (34)
30 – 34.9	29,113 (23)	20,823 (24)	22,247 (24)
35 – 39.9	15,700 (12)	11,646 (14)	12,195 (13)
40	8378 (6)	6333 (7)	6425 (7)
Number of comorbidities ^{b, c}			
0	22,635 (18)	25,093 (29)	14,851 (16)
1	22,332 (17)	26,123 (30)	16,069 (17)
2	26,387 (20)	17,600 (21)	19,663 (21)
3	23,282 (18)	9780 (11)	17,454 (19)
4	34,404 (27)	7524 (9)	25,239 (27)
Bachelor's degree or higher (census block group %) ^a			
<15	25,885 (20)	17,258 (20)	18,419 (20)
15 – 24	26,444 (20)	17,606 (20)	19,020 (20)
25 – 49	50,952 (39)	34,108 (40)	37,147 (40)
50	25,563 (20)	17,036 (20)	18,579 (20)
Household income (census block group median \$) ^a			
<30,000	5856 (5)	3811 (4)	4025 (4)
30,000 – 49,999	28,100 (22)	18,566 (21)	19,973 (21)

Characteristic	All patients, n=129,040 (%)	Patients with 2 dispensings of an ACEI/ARB, n=86,120 (%)	Patients with 2 dispensings of a statin, n=93,276 (%)
50,000 – 69,999	34,211 (27)	22,929 (27)	24,754 (27)
70,000 – 89,999	27,764 (21)	18,624 (22)	20,282 (22)
90,000	32,908 (25)	22,075 (26)	24,128 (26)
Number of unique medication classes at start of year, mean (SD)	5.3 (3.5)	5.9 (3.3)	5.9 (3.3)
Mean days' supply of ACEI/ARB or statin dispensed at each dispensing ^d			
<31	Not applicable	3526 (4)	4140 (4)
31 – 60	Not applicable	4732 (5)	4654 (5)
61 – 90	Not applicable	17,729 (21)	39,813 (43)
>90	Not applicable	60,133 (70)	44,669 (48)
ACEI/ARB or statin refilled via mail order pharmacy (% in year)			
0	Not applicable	39,474 (46)	42,250 (45)
1 – 50	Not applicable	8463 (10)	8811 (10)
51	Not applicable	38,183 (44)	42,215 (45)
Generic co-pay for 30 day supply > \$10	12,022 (9)	7701 (9)	8341 (9)
Annual out-of-pocket maximum > \$2000	54,737 (42)	36,343 (42)	39,496 (42)

ACEI/ARB=angiotensin- converting enzyme inhibitors/angiotensin receptor blockers.

^aRace/ethnicity was not available for 9% of the cohort; body mass index was not available for 6%; census data was not available for < 1%; generic drug co-payment was not available for 3%.

^bComorbidity count for patients with 2 dispensings of an ACEI/ARB; excludes complicated diabetes and chronic kidney dysfunction.

^cThe numbers and % of patients with each individual comorbidity are shown in the Supplementary Table.

^d33% of the cohort had no ACEI/ARB dispensing; 28% of the cohort had no statin dispensing.

Table 2

Associations Between Adherence to ACEI/ARB or Adherence to Statins and Age, Comorbidities, and Other Selected Characteristics Among Elderly Patients With Diabetes

Characteristic	Risk ratio (95% confidence interval) ^a	
	ACEI/ARB (n=84,452) ^{b, c}	Statins (n=91,484) ^d
Age in years (reference: 65 – 69)		
70 – 74	1.00 (0.99, 1.01)	1.01 (1.00, 1.02)
75 – 79	1.00 (0.99, 1.01)	1.02 (1.01, 1.03)
80 – 84	0.99 (0.98, 1.00)	1.02 (1.01, 1.03)
85	0.99 (0.97, 1.00)	1.02 (1.01, 1.03)
Number of comorbidities (reference: 0)		
1	0.97 (0.97, 0.98)	0.97 (0.96, 0.99)
2	0.95 (0.94, 0.96)	0.97 (0.96, 0.98)
3	0.91 (0.90, 0.92)	0.94 (0.93, 0.95)
4	0.88 (0.87, 0.89)	0.91 (0.90, 0.92)
Female	1.00 (1.00, 1.01)	0.97 (0.96, 0.97)
Race/ethnicity (reference: White)		
Asian	0.99 (0.98, 1.00)	1.00 (0.99, 1.01)
Black	0.96 (0.95, 0.97)	0.92 (0.90, 0.93)
Native Hawaiian/Pacific Islander	0.92 (0.87, 0.97)	0.94 (0.89, 0.99)
American Indian/Alaskan Native	0.99 (0.93, 1.05)	0.95 (0.89, 1.02)
Hispanic	0.98 (0.96, 0.99)	0.96 (0.95, 0.97)
Body mass index (kg/m ²)(reference: 18 – 24.9)		
< 18	0.95 (0.89, 1.01)	0.96 (0.90, 1.01)
25 – 29.9	1.01 (1.00, 1.02)	1.01 (1.00, 1.02)
30 – 34.9	1.02 (1.01, 1.03)	1.01 (1.00, 1.02)
35 – 39.9	1.02 (1.00, 1.03)	1.00 (0.98, 1.01)
40	1.00 (0.99, 1.02)	1.00 (0.98, 1.01)
Missing	1.06 (1.04, 1.08)	1.05 (1.03, 1.07)
Number of unique medication classes (at start of year)	1.01 (1.01, 1.02)	1.02 (1.02, 1.02)
Days' supply at each dispensing (reference: < 31)		
31 – 60	1.13 (1.09, 1.18)	1.13 (1.09, 1.17)
61 – 90	1.35 (1.31, 1.39)	1.46 (1.42, 1.51)
> 90	1.60 (1.54, 1.65)	1.60 (1.55, 1.65)
Refilled via mail order pharmacy (% in year)(reference: 0)		
1 – 50	0.97 (0.96, 0.98)	0.98 (0.97, 0.99)
51 – 100	1.07 (1.06, 1.07)	1.07 (1.06, 1.08)
Annual individual out-of-pocket maximum (\$)(reference > 2000)		
0 – 2000	1.02 (1.01, 1.03)	1.02 (1.01, 1.02)

ACEI/ARB=angiotensin-converting enzyme inhibitors/angiotensin receptor blockers.

^a Adjusted for site and whether patient was enrolled in the health plan for all 12 months of 2010. Education, household income, and generic drug co-payment for 30 day supply were also included in the models but as they were not significant, the risk ratio and 95% confidence intervals for those variables are not shown.

^b 86,120 patients had 2 dispensings of ACEI/ARB; 1668 patients had missing values for census block group variables and/or generic drug co-payment and were not included in this analysis.

^c Count of comorbidities excludes chronic kidney disease and complicated diabetes.

^d 93,276 patients had 2 dispensings of a statin; 1792 patients had missing values for census block group variables and/or generic drug co-payment and were not included in this analysis.