Racial differences in statin adherence following hospital discharge for ischemic stroke

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ABSTRACT

Objective: To compare nonadherence to statins in older black and white adults following an ischemic stroke.

Methods: We studied black and white adults ≥66 years of age with Medicare fee-for-service insurance coverage hospitalized for ischemic stroke from 2007 to 2012 who filled a statin prescription within 30 days following discharge. Nonadherence was defined as a proportion of days covered <80% in the 365 days following hospital discharge. In addition, we evaluated factors associated with nonadherence for white and black participants separately.

Results: Overall 2,763 beneficiaries met the inclusion criteria (13.5% black). Black adults were more likely than white adults to be nonadherent (49.7% vs 41.5%) even after adjustment for demographics, receipt of a low-income subsidy, and baseline comorbidities (adjusted relative risk [RR] 1.14, 95% confidence interval [CI] 1.01–1.29). Among white adults, receipt of a low-income subsidy (adjusted RR 1.13, 95% CI 1.02–1.26), history of coronary heart disease (adjusted RR 1.15, 95% CI 1.01–1.30), and discharge directly home following stroke hospitalization (adjusted RR 1.26, 95% CI 1.10–1.44) were associated with a higher risk of nonadherence. Among black adults, a 1-unit increase in the Charlson comorbidity index (adjusted RR 1.04, 95% CI 1.01–1.09), history of carotid artery disease (adjusted RR 2.38, 95% CI 1.08–5.25), and hospitalization during the 365 days prior to the index stroke (adjusted RR 1.34, 95% CI 1.01–1.78) were associated with nonadherence.

Conclusions: Compared with white adults, black adults were more likely to be nonadherent to statins following hospitalization for ischemic stroke. ***Neurology*® 2017;88:1839–1848**

GLOSSARY

CHD = coronary heart disease; **CI** = confidence interval; **CMS** = Centers for Medicare and Medicaid Services; **ICD-9-CM** = *International Classification of Diseases–9–clinical modification*; **IPR** = inpatient rehabilitation; **LIS** = low-income cost subsidy; **PDC** = proportion of days covered; **RR** = relative risk; **SNF** = skilled nursing facility.

Each year, 795,000 people in the United States experience a new or recurrent stroke.[1] Stroke is a leading cause of long-term adult disability and has estimated total direct medical costs of $71.6 billion.[2] The majority of strokes in the United States are ischemic, with 7%–21% of those surviving an initial stroke having a recurrent event within 1 year.[3] Studies show that recurrent stroke is even more disabling and costly than the first event.[4] Currently there are an estimated 7 million adult stroke survivors in the United States, underscoring the importance of secondary stroke prevention.[1]

The Stroke Prevention by Aggressive Reduction in Cholesterol Levels trial demonstrated that statin treatment reduces the risk for recurrent stroke in patients with a history of stroke or TIA.[5] Furthermore, a meta-analysis of placebo-controlled and active-comparator trials has shown that statins reduce the risk of stroke in patients with coronary heart disease (CHD).[6] Despite the efficacy of statins for stroke prevention, analyses of registry data suggest that many patients discontinue statin therapy within 1 year of stroke hospital discharge.[7] While previous studies have shown that black adults are less adherent to statins than white adults following myocardial

Supplemental data at Neurology.org

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infarction,[8] there are few data on racial differences in statin adherence following ischemic stroke. Determining the factors associated with nonadherence in community-dwelling white and black stroke survivors can guide interventions to improve adherence. Therefore, we conducted a retrospective cohort study to compare statin nonadherence in black and white adults following hospitalization for ischemic stroke. In addition, we determined whether factors associated with statin nonadherence differed for black and white adults. We hypothesized that a higher percentage of black than white adults would be nonadherent and that black and white adults would have different factors associated with statin nonadherence.

METHODS

Data source. Using the 5% sample from the Centers for Medicare and Medicaid Services (CMS), we conducted a retrospective cohort study of white and black Medicare beneficiaries hospitalized for an ischemic stroke between January 1, 2007, and December 31, 2012. Data were obtained from Medicare enrollment, inpatient (Medicare part A), outpatient (Medicare part B), and prescription drug (Medicare part D) files.

Standard protocol approvals, registrations, and patient consents. The CMS and the institutional review board at the University of Alabama at Birmingham approved the study.

Inclusion/exclusion criteria. The current analysis included Medicare beneficiaries with an ischemic stroke (index event), defined by having ICD-9-CM codes 433.x1, 434.x1, or 436 in any discharge diagnosis position in an inpatient file claim. Beneficiaries were required to have continuous full fee-for-service coverage, defined as Medicare parts A, B, and D during the 365-day look-back period prior to hospital admission for the index stroke event, during the stroke hospitalization, and for the 365 days after discharge. Beneficiaries enrolled in Medicare Advantage plans (Medicare part C coverage) were excluded as complete claims were not available for this population.

Additional eligibility for the current analysis included the following: (1) an acute care hospital length of stay for the index stroke of less than or equal to 30 days, (2) no claims for hospice care in the look-back period or in the 365 days after discharge, (3) no hospitalization for ischemic stroke during the 365-day look-back period prior to hospital admission for the index stroke event,[9] (4) no statin use in the 365 days before the ischemic stroke hospitalization event and no statin fills during hospitalization, (5) living in the United States during the entire look-back period through 365 days after hospital discharge and having valid birth and death dates, (6) alive for 365 days following hospital discharge for the index stroke event, (7) age at least 66 years but less than 110 years at the time of hospital admission for the index stroke event, and (8) self-reported race as black or white. If a Medicare beneficiary had more than one hospitalization for ischemic stroke meeting these inclusion criteria, only the earliest eligible hospitalization was included. We restricted the analysis to Medicare beneficiaries initiating statins following their index stroke event as adherence differs between prevalent and new statin users.[10,11] Among Medicare beneficiaries meeting these criteria (n = 7,330), we excluded 4,567 beneficiaries who did not have a Medicare Part D claim for a statin within 30 days of hospital discharge following their stroke, resulting in a sample of 2,763 Medicare beneficiaries for the analyses (figure).

Exposure/covariates. Age, self-reported race, and sex were obtained from the Medicare beneficiary enrollment file. Receipt of a low-income cost subsidy (LIS), a marker of low socioeconomic status, was obtained from the Part D summary file. Diabetes, heart failure, dementia, depression, and Charlson comorbidity index were defined using claims during the look-back period and previously published algorithms.[12,13] The algorithm used to define each covariate is shown in table e-1 at Neurology.org.[12–16] Hospitalizations during the look-back period were identified using Part A claims. The type and dose of the first statin filled were determined using Medicare Part D claims. Covariates assessed following hospital discharge for the index stroke event included any inpatient rehabilitation (IPR) and skilled nursing facility (SNF) stays with an admission to IPR or SNF within 7 days of hospital discharge.

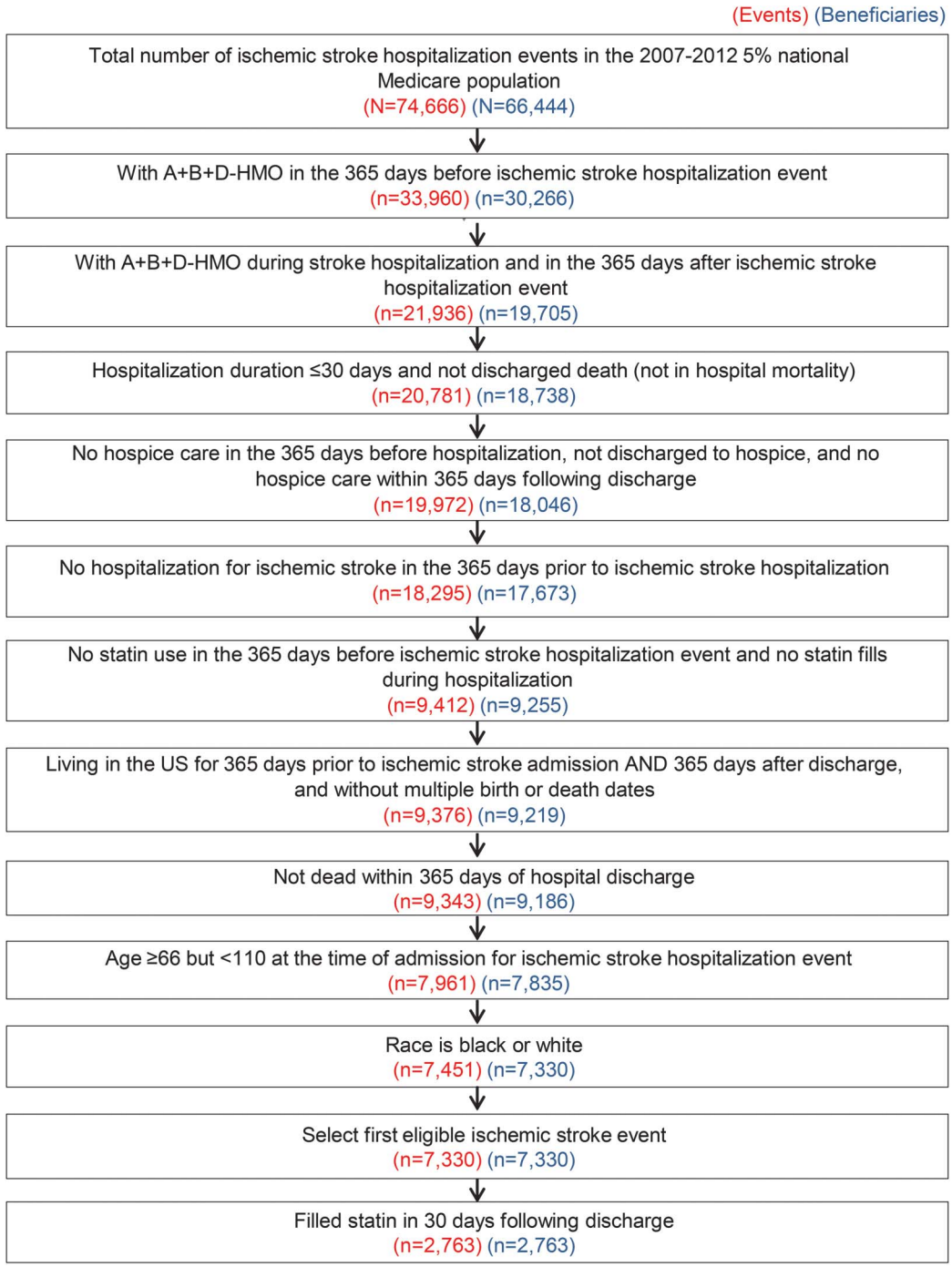
Outcome: Statin nonadherence. Statin fills were identified using Medicare Part D claims. Nonadherence was determined by calculating the proportion of days covered (PDC), a metric recommended by the Pharmacy Quality Alliance.[17] The PDC was calculated as the number of days for which a day of statin supply was available from the date of the first fill through 365 days following hospital discharge for the index stroke divided by the number of days in this time period. Time spent in inpatient rehabilitation, SNF, or in the hospital was excluded from the PDC calculations. Nonadherence was defined as a PDC $<80\%$.[17]

Statistical analysis. Characteristics of the cohort were calculated overall and by race. The median PDC was calculated for black and white adults. The difference in median PDC between black and white adults was calculated using quantile regression with 3 levels of adjustment. The crude difference in the median PDC was calculated, followed by a second model that included adjustment for age and sex, and a third model that also included adjustment for age, sex, LIS, Charlson comorbidity index, atrial fibrillation, hypertension, hyperlipidemia, diabetes, carotid artery disease, coronary heart disease, heart failure, chronic kidney disease, dementia, depression, hospitalization for any cause during baseline period, number of medications prior to ischemic stroke hospitalization, anticoagulant use during baseline, antiplatelet use during baseline, length of stay, discharged home, any inpatient rehabilitation, type of first statin filled, dose of first statin filled, and calendar year of qualifying stroke. The prevalence of statin nonadherence was calculated for black and white adults, separately, and compared using a χ^2 test. Relative risks (RR) for nonadherence comparing black to white adults were calculated using generalized linear models with a Poisson distribution, a log link, and a robust variance estimator.[18] Models included 3 levels of adjustment, as described above. In a secondary analysis, RRs for statin nonadherence associated with factors from the look-back period, first statin filled, dose of first statin filled, and year of stroke were calculated for white and black adults, separately. All analyses were conducted using SAS 9.4 (SAS Institute, Research Triangle Park, NC).

RESULTS

Cohort characteristics. Among Medicare beneficiaries included in the current analysis (n = 2,763), black adults were younger, more frequently received a LIS, had a higher median Charlson comorbidity index, had a lower prevalence of atrial

Figure Flow diagram for the analysis: Medicare beneficiaries in the statin-naive stroke cohort



fibrillation, and had a higher prevalence of hypertension, diabetes, heart failure, chronic kidney disease, and dementia when compared to white adults (table 1). Black adults were less likely to be taking anticoagulants during the look-back period and had a longer length of stay during the index stroke than white adults. There were no statistically significant differences in the proportion of black and white adults who were discharged directly home, to inpatient rehabilitation, or to a SNF following hospital discharge. The first statin filled was a low-dose intensity for 15.0% of white adults and 9.4% of black adults. Nonstatin lipid-lowering agents were filled during the follow-up period by 7.2% of white adults and 4.0% of black adults.

Factors associated with nonadherence in white and black participants. The median PDC was 87.5 for white adults and 80.5 for black adults (table e-2; $p < 0.001$). After multivariable adjustment, the median PDC was −6.66% (95% confidence interval [CI] −12.2% to −1.12%) lower in black adults compared

Table 1 Characteristics of Medicare beneficiaries initiating statins after an ischemic stroke by race (n = 2,763)

	All (n = 2,763)	White adults (n = 2,389)	Black adults (n = 374)	p Value
Age, y	77.9 (7.5)	78.1 (7.5)	76.5 (7.6)	<0.001
Male sex	979 (35.4)	856 (35.8)	123 (32.9)	0.268
Low-income subsidy	956 (34.6)	675 (28.3)	281 (75.1)	<0.001
Charlson comorbidity index[a]	2 (0, 4)	2 (0, 4)	3 (1, 5)	<0.001
History of atrial fibrillation	383 (13.9)	355 (14.9)	28 (7.5)	<0.001
History of hypertension	1,454 (52.6)	1,215 (50.9)	239 (63.9)	<0.001
History of hyperlipidemia	373 (13.5)	333 (13.9)	40 (10.7)	0.088
History of diabetes	629 (22.8)	498 (20.8)	131 (35.0)	<0.001
History of carotid artery disease	21 (0.8)	19 (0.8)	b	0.590
History of coronary heart disease	553 (20.0)	484 (20.3)	69 (18.4)	0.416
History of heart failure	226 (8.2)	183 (7.7)	43 (11.5)	0.012
History of chronic kidney disease	332 (12.0)	253 (10.6)	79 (21.1)	<0.001
History of dementia	233 (8.4)	186 (7.8)	47 (12.6)	0.002
History of depression	161 (5.8)	143 (6.0)	18 (4.8)	0.368
Hospitalization for any cause during look-back period	604 (21.9)	523 (21.9)	81 (21.7)	0.919
No. of medications prior to ischemic stroke hospitalization	7.9 (5.8)	7.9 (5.8)	7.8 (6.0)	0.694
Anticoagulant use during look-back period	230 (8.3)	217 (9.1)	13 (3.5)	<0.001
Antiplatelet use during look-back period	262 (9.5)	228 (9.5)	34 (9.1)	0.781
Length of stay, d	7.8 (7.5)	7.6 (7.4)	9.1 (7.9)	<0.001
Discharged home	2,174 (78.7)	1,878 (78.6)	296 (79.1)	0.815
Have inpatient rehabilitation	662 (24.0)	565 (23.7)	97 (25.9)	0.336
Skilled nursing facility stay	552 (20.0)	480 (20.1)	72 (19.3)	0.705
Type of first statin filled				
Simvastatin	1,598 (57.8)	1,371 (57.4)	227 (60.7)	0.440
Atorvastatin	699 (25.3)	608 (25.4)	91 (24.3)	
Pravastatin	270 (9.8)	234 (9.8)	36 (9.6)	
Rosuvastatin	140 (5.1)	128 (5.4)	12 (3.2)	
Other statin (fluvastatin, lovastatin, pitavastatin)	56 (2.0)	48 (2.0)	b	
Dose of first statin filled				
High	424 (15.3)	363 (15.2)	61 (16.3)	0.014
Intermediate	1,945 (70.4)	1,667 (69.8)	278 (74.3)	
Low	394 (14.3)	359 (15.0)	35 (9.4)	
Change/switch in the type of statin filled in 365-day follow-up period				
Any change in statin	331 (12.0)	293 (12.3)	38 (10.2)	0.244
No. of statin types	1.13 (0.35)	1.13 (0.35)	1.11 (0.34)	0.325
Nonstatin lipid-lowering drug use	188 (6.8)	173 (7.2)	15 (4.0)	0.021
Year of qualifying stroke				
2007	344 (12.5)	301 (12.6)	43 (11.5)	0.173
2008	444 (16.1)	375 (15.7)	69 (18.4)	
2009	469 (17.0)	393 (16.5)	76 (20.3)	
2010	469 (17.0)	417 (17.5)	52 (13.9)	

Continued

Table 1 Continued

	All (n = 2,763)	White adults (n = 2,389)	Black adults (n = 374)	p Value
2011	533 (19.3)	467 (19.5)	66 (17.6)	
2012	504 (18.2)	436 (18.3)	68 (18.2)	

Values are expressed as n (%), except for age, number of medications prior to hospitalization, length of stay, and number of statin types, which are expressed as mean (SD).
[a] Charlson comorbidity index is expressed as median (25th percentile, 75th percentile).
[b] Indicates that the data have been suppressed because there are fewer than 11 Medicare beneficiaries in the cell. *p* Value reflects the comparison between black and white adults.

with white adults. Forty-three percent of ischemic stroke survivors were nonadherent to statins in the year following hospital discharge. When compared with white adults, a higher percentage of black adults were nonadherent to their statin (49.7% vs 41.5%, $p = 0.003$; table 2). This association remained present after multivariable adjustment (black:white RR 1.14, 95% CI 1.00–1.29).

Characteristics of white and black adults who were adherent and nonadherent to statins are shown in table 3. After multivariable adjustment, the factors associated with statin nonadherence among white adults included receipt of a LIS (RR 1.13, 95% CI 1.02–1.26), a history of CHD (RR 1.15, 95% CI 1.01–1.30), and being discharged directly home following ischemic stroke hospitalization (RR 1.26, 95% CI 1.10–1.44, table 4). Among black adults, each one point higher Charlson comorbidity index (RR 1.04, 95% CI 1.01–1.09), history of carotid artery disease (RR 2.38, 95% CI 1.08–5.25), and hospitalization during the look-back period (RR 1.34, 95% CI 1.01–1.78) were associated with statin nonadherence after multivariable adjustment.

DISCUSSION There are several important findings from this study. First, nonadherence to statins was common in the year following hospital discharge for an ischemic stroke and did not improve between 2007 and 2012. Second, black adults were more likely to be nonadherent to statins compared with white adults. This finding remained after adjustment for beneficiary demographics, comorbidities, and proxies of stroke severity. Third, factors associated with statin nonadherence differed for white and black adults. Among white adults, LIS, history of coronary heart disease, and discharge home were associated with statin nonadherence. In black adults, a higher Charlson comorbidity index, hospitalization in the look-back period, and history of carotid artery disease were associated with statin nonadherence. This suggests that white and black adults may have different barriers to medication adherence and that efforts aimed at improving medication adherence may require race-specific interventions.

Prior estimates of statin nonadherence among people in the year following ischemic stroke and TIA have varied widely.[7,19] This variation may be due in part to the reliance on self-report for assessing adherence,[19] the inclusion of patients who have no lasting disability from their cerebral ischemia (TIA),[19] younger patients,[19] a small proportion of black adults,[7] or being performed in countries where the health care system is inherently different from the US system.[7] In the current study, 43% of ischemic stroke survivors were nonadherent to statins in the year following hospital discharge. These data underscore that statin nonadherence is a major challenge for patients following ischemic stroke.

Prior research has shown that statin nonadherence in the general population is associated with an increased risk for cardiovascular disease–related hospitalizations and higher health care costs.[20] Given the association of nonadherence with increased morbidity and mortality,[21] health care providers should be adequately trained to screen for and recognize medication nonadherence. Screening for medication nonadherence is not routinely performed by physicians.[22] Even when screening is performed, physicians often have a difficult time recognizing nonadherence.[23] Prior studies suggest that physicians'

Table 2 Statin nonadherence in white and black Medicare beneficiaries following an ischemic stroke

Model	White adults (n = 2,389)	Black adults (n = 374)
Non-adherent, n (%)	991 (41.5)	186 (49.7)
Crude, RR (95% CI)	1 (ref)	1.20 (1.07, 1.34)
Age and sex adjustment, RR (95% CI)	1 (ref)	1.19 (1.07, 1.34)
Full adjustment, RR (95% CI)[a]	1 (ref)	1.14 (1.00, 1.29)

Abbreviations: CI = confidence interval; PDC = proportion of days covered; RR = relative risk.
[a] Adjusted for age, sex, low-income subsidy, Charlson comorbidity index, atrial fibrillation, hypertension, hyperlipidemia, diabetes, carotid artery disease, coronary heart disease, heart failure, chronic kidney disease, dementia, depression, hospitalization for any cause during baseline period, number of medications prior to ischemic stroke hospitalization, anticoagulant use during baseline, antiplatelet use during baseline, length of stay, discharged home, any inpatient rehabilitation, type of first statin filled, dose of first statin filled, and calendar year of qualifying stroke.

Table 3 Characteristics of Medicare beneficiaries initiating statins following an ischemic stroke by adherence and race (n = 2,763)

	White adults (n = 2,389)			Black adults (n = 374)		
Characteristics	Nonadherent (n = 991)	Adherent (n = 1,398)	*p* Value	Nonadherent (n = 186)	Adherent (n = 188)	*p* Value
Age, y[a]	78.0 (7.4)	78.2 (7.5)	0.589	75.7 (7.4)	77.3 (7.7)	0.047
Male sex	358 (36.1)	498 (35.6)	0.801	68 (36.6)	55 (29.3)	0.133
Low-income subsidy	305 (30.8)	370 (26.5)	0.021	142 (76.3)	139 (73.9)	0.590
Charlson comorbidity index[b]	2 (1, 4)	2 (0, 4)	0.019	3 (1, 6)	3 (1, 5)	0.329
History of atrial fibrillation	168 (17.0)	187 (13.4)	0.015	c	20 (10.6)	0.020
History of hypertension	512 (51.7)	703 (50.3)	0.507	116 (62.4)	123 (65.4)	0.538
History of hyperlipidemia	153 (15.4)	180 (12.9)	0.075	16 (8.6)	24 (12.8)	0.193
History of diabetes	226 (22.8)	272 (19.5)	0.047	65 (34.9)	66 (35.1)	0.974
History of carotid artery disease	c	11 (0.8)	0.956	c	c	0.994
History of coronary heart disease	233 (23.5)	251 (18.0)	0.001	36 (19.4)	33 (17.6)	0.653
History of heart failure	86 (8.7)	97 (6.9)	0.115	22 (11.8)	21 (11.2)	0.842
History of chronic kidney disease	110 (11.1)	143 (10.2)	0.495	37 (19.9)	42 (22.3)	0.562
History of dementia	78 (7.9)	108 (7.7)	0.896	25 (13.4)	22 (11.7)	0.612
History of depression	54 (5.4)	89 (6.4)	0.352	c	c	0.981
Hospitalization for any cause during baseline period	231 (23.3)	292 (20.9)	0.158	47 (25.3)	34 (18.1)	0.092
No. of medications prior to ischemic stroke hospitalization[a]	8.1 (5.9)	7.7 (5.7)	0.192	7.6 (6.0)	7.9 (6.1)	0.710
Anticoagulant use during look-back period	101 (10.2)	116 (8.3)	0.112	c	11 (5.9)	0.012
Antiplatelet use during look-back period	108 (10.9)	120 (8.6)	0.058	17 (9.1)	17 (9.0)	0.974
Length of stay, d[a]	7.5 (7.4)	7.7 (7.4)	0.663	7.9 (7.3)	10.2 (8.4)	0.005
Discharged home	812 (81.9)	1,066 (76.3)	0.001	153 (82.3)	143 (76.1)	0.140
Have inpatient rehabilitation	231 (23.3)	334 (23.9)	0.742	41 (22.0)	56 (29.8)	0.088
Skilled nursing facility stay	171 (17.3)	309 (22.1)	0.004	30 (16.1)	42 (22.3)	0.128
Type of first statin filled						
Simvastatin	562 (56.7)	809 (57.9)	0.828	108 (58.1)	119 (63.3)	0.227
Atorvastatin	260 (26.2)	348 (24.9)		46 (24.7)	45 (23.9)	
Pravastatin	92 (9.3)	142 (10.2)		17 (9.1)	19 (10.1)	
Rosuvastatin	57 (5.8)	71 (5.1)		c	c	
Other statin (fluvastatin, lovastatin, pitavastatin)	20 (2.0)	28 (2.0)		c	c	
Dose of first statin filled						
High	154 (15.5)	209 (14.9)	0.700	36 (19.4)	25 (13.3)	0.274
Intermediate	695 (70.1)	972 (69.5)		134 (72.0)	144 (76.6)	
Low	142 (14.3)	217 (15.5)		16 (8.6)	19 (10.1)	
Change/switch in the type of statin filled in 365-day follow-up period						
Any change in statin	137 (13.8)	156 (11.2)	0.050	26 (14.0)	12 (6.4)	0.015
No. of statin types	1.15 (0.37)	1.12 (0.34)	0.057	1.15 (0.39)	1.07 (0.27)	0.020
Addition of nonstatin lipid-lowering drug in 365-day follow-up period						
Any nonstatin added	83 (8.4)	90 (6.4)	0.072	c	c	0.417
Year of qualifying stroke						
2007	120 (12.1)	181 (12.9)	0.543	22 (11.8)	21 (11.2)	0.314
2008	149 (15.0)	226 (16.2)		31 (16.7)	38 (20.2)	
2009	158 (15.9)	235 (16.8)		46 (24.7)	30 (16.0)	

Continued

Table 3 Continued

Characteristics	White adults (n = 2,389)			Black adults (n = 374)		
	Nonadherent (n = 991)	Adherent (n = 1,398)	*p* Value	Nonadherent (n = 186)	Adherent (n = 188)	*p* Value
2010	171 (17.3)	246 (17.6)		27 (14.5)	25 (13.3)	
2011	212 (21.4)	255 (18.2)		28 (15.1)	38 (20.2)	
2012	181 (18.3)	255 (18.2)		32 (17.2)	36 (19.1)	

[a] Values are expressed as n (%) except for age, number of medications prior to hospitalization, length of stay, and number of statin types, which are expressed as mean (SD).
[b] Charlson comorbidity index is expressed as median (25th percentile, 75th percentile).
[c] Indicates that the data have been suppressed because there are fewer than 11 Medicare beneficiaries in the cell.

ability to recognize medication nonadherence can be improved by providing them with access to pharmacy refill data.[24] Cost-related nonadherence to medication in adult stroke survivors occurs in 1 in 6 black adults and 1 in 10 white adults.[25] Elimination of prescription copayment has been shown to improve adherence for patients following myocardial infarction.[26] Two additional strategies that can be employed to improve adherence are the use of mail-order pharmacies and 90-day prescriptions. Observational studies show that these approaches are associated with higher medication adherence.[27,28] The high incidence of statin nonadherence among stroke survivors in the current study highlights the need for health care providers to screen for nonadherence and assist patients in addressing barriers to statin nonadherence.

The higher incidence of statin nonadherence among black adults compared with white adults is consistent with the findings of a recent meta-analysis that reported that nonwhite adults were at higher risk of nonadherence compared with white adults.[29] Prior studies have reported that older individuals,[30] women,[31] and individuals with low income,[30] depression,[30] polypharmacy,[30] and less morbidity[30] are less likely to be adherent; the association we observed between black race and statin nonadherence did not change appreciably after adjustment for these variables. Reasons for racial differences in adherence likely extend beyond demographics, socioeconomic status, and comorbidities.[32] Physician communication behaviors have been shown to affect patient trust, particularly in race discordance between patients and physicians.[33] A recent meta-analysis suggested that the risk of nonadherence is higher in patients who have a physician who communicates poorly.[34] Studies have shown that training physicians in patient-centered communication skills has the potential to improve patient adherence to treatment.[32,34]

In the current study, risk factors for statin nonadherence differed by race. For example, having LIS was associated with statin nonadherence in white adults, but not in black adults. Reasons for differential statin nonadherence between black and white stroke survivors are likely multifactorial and may include, but are not limited to, reduced access to physicians,[35] lower quality of medical care,[36] and lack of trust in providers and the health care system.[35]

Qualitative interviews of black patients with hypertension revealed that patient-specific barriers such as beliefs and attitudes about the disease and medications, as well as forgetfulness, were the most commonly cited barriers to medication adherence.[37] Additional research in black adults with hypertension has shown that perceived discrimination is associated with medication nonadherence and that stress and depression may mediate this association.[38] Understanding the barriers to medication adherence has important policy and practice implications that warrant further exploration and testing. To improve outcomes, contain health care costs, and limit preventable recurrent events, it is essential to identify populations at high risk for statin nonadherence and to develop interventions that can improve adherence.

The current study has several strengths. The majority of US adults ≥65 years of age have health insurance through Medicare, providing high generalizability to older adults in the United States. Utilizing a 365-day look-back period allowed us to identify comorbidities present prior to the index stroke. Pharmacy fill data provided an objective adherence measure that is not subject to recall bias.[17] The current study also has limitations. Medicare beneficiaries may have limited generalizability to younger adults; however, most US adults having stroke are 65 years of age or older. Lack of evidence of a statin claim in the look-back period cannot guarantee first ever statin use.[39] Although we required a 1-year period with no statin fills, beneficiaries could have taken statins in the more distant past. Those with a history of CHD in the current study may have been on a statin previously and discontinued due to side effects. These beneficiaries would be more likely to be nonadherent to their statin following a stroke event. It is also possible that beneficiaries filled a statin outside of

Table 4 Race-specific relative risks for nonadherence among Medicare beneficiaries initiating statins following an ischemic stroke (n = 2,763)

	White adults	Black adults
Age, per 5 y	1.00 (0.96–1.03)	0.94 (0.87–1.01)
Male sex	0.99 (0.89–1.10)	1.11 (0.90–1.37)
Low-income subsidy	1.13 (1.02–1.26)	1.06 (0.83–1.37)
Charlson comorbidity index	1.01 (0.99–1.04)	1.04 (1.01–1.09)
History of atrial fibrillation	1.11 (0.95–1.29)	0.57 (0.31–1.04)
History of hypertension	0.99 (0.89–1.10)	0.94 (0.75–1.19)
History of hyperlipidemia	1.08 (0.94–1.23)	0.80 (0.54–1.20)
History of diabetes	1.05 (0.93–1.19)	0.94 (0.74–1.19)
History of carotid artery disease	0.90 (0.53–1.53)	2.38 (1.08–5.25)
History of coronary heart disease	1.15 (1.01–1.30)	1.02 (0.77–1.36)
History of heart failure	0.99 (0.82–1.19)	1.07 (0.75–1.53)
History of chronic kidney disease	0.94 (0.79–1.11)	0.86 (0.64–1.17)
History of dementia	1.00 (0.83–1.21)	0.97 (0.68–1.37)
History of depression	0.89 (0.71–1.11)	1.06 (0.64–1.76)
Hospitalization for any cause during baseline period	1.04 (0.91–1.18)	1.34 (1.01–1.78)
No. of medications prior to ischemic stroke hospitalization	1.00 (0.99–1.01)	0.99 (0.97–1.01)
Anticoagulant use during look-back period	1.04 (0.87–1.24)	0.36 (0.10–1.30)
Antiplatelet use during look-back period	1.08 (0.93–1.27)	0.96 (0.67–1.36)
Length of stay per 5 days	0.99 (0.94–1.05)	0.90 (0.80–1.01)
Discharged home	1.26 (1.10–1.44)	1.30 (0.96–1.75)
Have inpatient rehabilitation	0.98 (0.82–1.18)	1.07 (0.71–1.61)
First statin filled		
Simvastatin	1 (ref)	1 (ref)
Atorvastatin	1.05 (0.93–1.19)	1.01 (0.77–1.31)
Pravastatin	0.97 (0.81–1.16)	1.01 (0.69–1.50)
Rosuvastatin	1.05 (0.85–1.30)	1.51 (1.03–2.22)
Other statin (fluvastatin, lovastatin, pitavastatin)	1.05 (0.75–1.48)	1.52 (1.03–2.25)
Dose of first statin filled		
High	1 (ref)	1 (ref)
Intermediate	1.03 (0.89–1.19)	0.93 (0.71–1.23)
Low	0.98 (0.80–1.21)	0.85 (0.51–1.41)
Year of qualifying stroke		
2007	1 (ref)	1 (ref)
2008	1.00 (0.83–1.20)	0.84 (0.57–1.23)
2009	1.03 (0.86–1.24)	1.12 (0.79–1.60)
2010	1.05 (0.87–1.25)	1.07 (0.72–1.59)
2011	1.16 (0.97–1.37)	0.82 (0.55–1.22)
2012	1.06 (0.88–1.27)	0.87 (0.59–1.31)

Abbreviations: CI = confidence interval; RR = relative risk.
Values are expressed as RR (95% CI). Relative risks are adjusted for age, sex, low-income subsidy, Charlson comorbidity index, atrial fibrillation, hypertension, hyperlipidemia, diabetes, carotid artery disease, coronary heart disease, heart failure, chronic kidney disease, dementia, depression, hospitalization for any cause during baseline period, number of medications prior to ischemic stroke hospitalization, anticoagulant use during baseline, antiplatelet use during baseline, length of stay, discharged home, any inpatient rehabilitation, type of first statin filled, dose of first statin filled, and calendar year of qualifying stroke.

Medicare. Previous studies have suggested that up to 20% of beneficiaries may fill a statin without a claim being filed.[40] Information on several factors that can influence adherence, including adverse reactions to statins, creatine kinase levels, and glucose, are not available in Medicare claims.

In the current study, black adults were more likely than white adults to be nonadherent to statins in the year following stroke hospitalization. Factors associated with statin nonadherence differed for black and white adults. Identifying medication nonadherence and barriers to medication adherence has the potential to reduce the risk for recurrent events among the 7 million stroke survivors in the United States.

AUTHOR CONTRIBUTIONS

Karen Albright participated in the design or conceptualization of the study, interpretation of data, and drafted the manuscript. Hong Zhao performed the analysis and participated in revision of the manuscript. Justin Blackburn participated in the design or conceptualization of the study, interpretation of data, and revision of the manuscript. Nita Limdi participated in the design or conceptualization of the study and revision of the manuscript. T. Mark Beasley participated in the design or conceptualization of the study and revision of the manuscript. George Howard participated in the design or conceptualization of the study, interpretation of data, and revision of the manuscript. Vera Bittner participated in the design or conceptualization of the study and revision of the manuscript. Virginia Howard participated in the design or conceptualization of the study, interpretation of data, and revision of the manuscript. Paul Muntner participated in the design or conceptualization of the study, interpretation of data, and revision of the manuscript.

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