Trends and Racial Differences in First Hospitalization for Stroke and 30-day Mortality in the US Medicare Population from 1988-2013

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Abstract

Purpose: To determine whether there were temporal differences in the rates of first stroke hospitalizations and 30-day mortality after stroke between black and white Medicare enrollees.

Methods: We used a 20% sample of Medicare beneficiaries aged   65 years and described the annual rate of first hospitalization for ischemic and hemorrhagic strokes from years 1988 to 2013, as well as 30-day mortality after stroke hospitalization. We used linear tests of trend to determine whether stroke rates changed over time, and tested the interaction term between race and year to determine whether trends differed by race.

Results: We identified 1,009,057 incident hospitalizations for ischemic strokes and 147,817 for hemorrhagic strokes. Annual stroke hospitalizations decreased significantly over time for both blacks and whites, and in both stroke subtypes (p values for trend all <0.001). Reductions in stroke rates were comparable between blacks and whites: among men, the OR for the interaction term for race by year was 1.008 [1.004–1.012] for ischemic and 1.002 (95% CI 0.999–1.004) for hemorrhagic; for women, it was 1.000 [0.997–1.004] for ischemic and 1.003 (95% CI 1.001–1.006) for hemorrhagic. Both black men and women experienced greater improvements over time in terms of 30-day mortality after strokes.

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Conflicts of interest: none of the authors have conflicts of interest related to this work

Conclusions: Rates of incident hospitalizations for ischemic and hemorrhagic strokes fell significantly over a 25 year period for both black and white Medicare enrollees. Black men and women experienced greater improvements in 30-day mortality after both ischemic and hemorrhagic stroke.

Background

Stroke remains a leading cause of death in the United States, but its incidence and mortality have declined considerably over the past few decades(1–4). These improvements in outcomes coincide with an era of quality improvement initiatives, the development of stroke centers of excellence, the decline in tobacco smoking, and the increased use of risk-modifying medications(1, 4–6).

Progress, however, may not be equally distributed amongst individuals of different racial categories. Stroke risk in black Americans, for example, have consistently exceeded the risk observed in white Americans(4, 7). A wider prevalence of contributing clinical factors, such as hypertension, smoking, and diabetes, in addition to disparities in clinical management and socioeconomic factors, may contribute to this increased observed risk(8–11). Whether the disparities in stroke risk have changed over time is still in question, with studies finding conflicting results. Some data show that declines in stroke incidence have been similar between blacks and whites(4). Others have found that the improvements in stroke risk amongst blacks lags behind whites(7, 12). Whether there are differences in stroke-related mortality, too, is unclear(8, 13, 14).

Our study's objective was to describe temporal trends over a 25-year period in the US with regard to stroke hospitalization and short-term mortality after stroke hospitalization, comparing trends between black and white Medicare enrollees. We separately report data on the two major stroke subtypes, ischemic and hemorrhagic strokes.

Methods

Because there was no single nationally-representative database that contained comprehensive information on stroke events, clinical risk factors for stroke, and medication prevalence over time, our approach was to obtain relevant data from three separate databases that collected nationally-representative data from Medicare enrollees during the time period of interest. Specifically, we obtained data on stroke hospitalizations and 30-day mortality after hospitalizations from the Medicare Provider Analysis and Review (MedPAR) database, a 20% sample of fee-for service Medicare beneficiaries aged 65 years or older(15). Demographic information in the Medicare claims files come from the Medicare Enrollment Database maintained at the Center for Medicare and Medicaid Services Data Center. The variable "race" comes from the Master Beneficiary Record of the Social Security Administration, which beneficiaries complete at the time of registration using pre-defined options. To identify the population prevalence of risk factors for stroke in the US black and white Medicare enrollees, we used data from the nationally-representative Third National Health and Nutrition Examination Survey (NHANES) surveys, restricted to people aged 65 years or older and with Medicare coverage. Finally, to assess the prevalence of prescribed

medications used to modify stroke risk, we used data from the Medicare Current Beneficiary Survey (MCBS), a nationally-representative survey of patients enrolled in Medicare

Identification of stroke events

Stroke hospitalizations occurring between 1988 and 2013 were identified by searching the MedPAR database for hospitalizations with a primary *International Classification of Diseases 9th Revision, Clinical Modification* (ICD-9) discharge diagnosis code for stroke, and stratified as ischemic (ICD-9 codes 434.x and 436.x) or hemorrhagic (ICD-9 codes 430.x and 431.x). We excluded subjects living outside of the United States (n=13,392) or who were enrolled in a Medicare health maintenance organization (n=168,132), for which Medicare utilization data may be incomplete. Information on subject demographics (age, sex, race), region of residence (Midwest, Northeast, South, or West), and vital status were obtained from Medicare denominator files. Only subjects whose race was categorized as "white" or "black" were included in this study, as coding for other race categories was less reliable in these records(16). We also searched for specific ICD-9 discharge diagnosis codes documented during the hospitalization for medical conditions related to stroke outcomes and mortality, including the variables used to calculate a Charlson comorbidity risk score.

Determining the population prevalence of stroke risk factors

Population-level prevalence of risk factors for stroke in the 65 years or older Medicare population were obtained by analyzing data from the NHANES surveys from 1988 to 1994 as well as from the continuous NHANES survey from years 2001–2008 and 2011–2014. NHANES questionnaires were completed by non-institutionalized individuals from the civilian population and contain detailed information obtained through direct patient interview as well as physiologic assessments(17). In addition to reporting the prevalence of individual risk factors, we also calculated the estimated stroke risk for the population during that time period, using the Framingham stroke risk score. The Framingham stroke risk score estimates 10-year stroke risk(18) in men and women based on age, systolic blood pressure, antihypertensive treatment, diabetes mellitus, smoking status, cardiovascular disease, left ventricular hypertrophy(LVH), and atrial fibrillation. The Framingham stroke risk score was developed to predict all strokes (e.g., a combination of ischemic and hemorrhagic stroke subtypes). With the exception of LVH and atrial fibrillation, all variables used to calculate the Framingham risk score were available in NHANES. The prevalence of LVH was obtained from electrocardiograms obtained on NHANES participants from years 1988–1994 and for later years, extrapolated from the scientific literature(19, 20). Atrial fibrillation prevalence for each time period was calculated by using the published population prevalence in the Medicare population from years 1992–2002 and then imputing the estimated prevalence of atrial fibrillation for years outside of this time window assuming a linear trend(1, 12, 21). Although ischemic and hemorrhagic strokes have several overlapping risk factors, including advancing age, hypertension, and smoking, there are additional risk factors distinct to hemorrhagic stroke, such as traumatic injury, anticoagulant exposure, and brain aneurysms, data which were lacking in our study.

Determining the population prevalence of medication use

Several medications, namely, statins, antihypertensive drugs, and antiplatelet agents are known to play a role in modifying stroke risk. To obtain information on the prevalence of medication use among Medicare enrollees, we used the MCBS from years 1992 to 2012. The MCBS is a nationally-representative survey of patients enrolled in Medicare that contains self-reported information on prescription medications, pharmacy receipts, and medication containers provided to the interviewers, supplemented by Medicare Part D prescription data from years 2006–2012(22). We calculated the percent Medicare enrollees 65 years each year who reported taking antihypertensive medications (angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, beta-blockers, calcium channel blockers, diuretics, and other antihypertensive agents), statins, and non-aspirin antiplatelet medications (clopidogrel, ticlopidine). Because aspirin was available without prescription, its use was not fully captured by the MCBS and not included in this study.

Statistical Analysis

The primary outcomes of the study were first hospitalization for stroke after age 65 and 30-day mortality after stroke hospitalization. The primary predictor was race (black versus white). Only the first hospitalization for stroke per subject was considered in the analysis in order to focus on incident stroke. Annual hospitalization rates for first stroke, stratified by gender, were calculated as the number of strokes per 100,000 Medicare beneficiaries per year, with crude rates standardized to the age and sex distribution of the year 2000 population. The age-adjusted risk of stroke between blacks and whites was compared first using simple logistic regression. Next, a linear regression model was developed to determine whether the annual rate of first stroke hospitalization changed significantly over time, incorporating year as a quadratic function. Finally, to test whether the temporal change in stroke hospitalization rate differed by race, we tested the interaction term between race and year. This approach was next applied to the analysis of 30-day mortality after stroke hospitalization, using multivariable logistic regression to adjust for co-existing factors that may be associated with 30-day mortality. Variables included in the models of mortality were those plausibly related to stroke-mortality: age, region, comorbid conditions related to stroke (myocardial infarction, congestive heart failure, hypertension, diabetes mellitus, atrial fibrillation, vascular disease, hyperlipidemia), and mean Charlson comorbidity index(23).

To describe the population prevalence of specific risk factors for stroke and preventive medication use, we used the NHANES and MCBS. The prevalence of stroke risk factors, stratified by race, was obtained during four time periods: 1988–1994, 2001–2004, 2005–2008, and 2011–2014. The proportion of Medicare enrollees reporting use of statins, antihypertensive, and antiplatelet medications was calculated for each year between 1992 and 2012. Comparisons of categorical variables were performed using Chi-squared tests and comparisons of means were performed using t-tests.

SAS 9.2 statistical package (SAS Institute Inc, Cary, NC) was used for data analyses. This study was approved by the institutional review board of the University of California, San Francisco and waiver of informed consent was granted due to the nature of the study.

Results

Incidence and outcomes of ischemic stroke

We identified 1,009,057 hospitalizations for first ischemic stroke between 1988–2013, with 116,351 occurring among blacks and 892,706 among whites. The clinical characteristics of hospitalized patients with ischemic stroke are presented in eTables 1 and 2. A greater proportion of ischemic strokes came from the Southern region compared to other regions. Cardiovascular risk factors were common amongst patients with ischemic stroke, including hypertension, heart failure, diabetes mellitus, atrial fibrillation, and hyperlipidemia, particularly in more recent years (eTables 1 and 2).

Overall, black enrollees were at higher risk for ischemic stroke than whites, with an age-adjusted odds ratio (OR) of 1.36 (95% confidence interval [CI], 1.30–1.43) for black men compared to white men, and OR 1.47 (95% CI, 1.41–1.53) for black women compared to white women. The annual rate of first ischemic stroke hospitalizations declined significantly over time for both blacks and whites (p values for trend <0.001, Figure 1a). The reductions in stroke rates were slightly greater for black men: OR for the interaction term of race by year 1.008 [1.004–1.012] for men and 1.000 [0.997–1.004] for women.

Both blacks and whites also experienced improvements in 30-day mortality after hospitalization for ischemic stroke (Figure 2). Both black men and black women experienced slightly greater improvements in 30-day mortality after ischemic stroke: for white men, ischemic stroke mortality fell from 16.4% in 1988 to 11.8% in 2013 and from 16.1% to 8.1% for black men (p values for trend <0.001, OR of the interaction term of black race by year 0.986 [95% CI, 0.982 – 0.990]). For women: ischemic stroke mortality declined from 16.0% to 14.8% in white women and 13.8% to 8.7% in black women (p values for trend <0.001, OR for interaction term 0.981 [95% CI, 0.977 – 0.986]).

Incidence and outcomes of hemorrhagic stroke

We identified 147,817 hospitalizations for first hemorrhagic stroke over the time period, 14,237 occurring among blacks and 133,580 among whites. Clinical characteristics of hospitalized patients with hemorrhagic stroke are presented in eTables 3 and 4. Similar to ischemic strokes, a greater proportion of hemorrhagic strokes came from the Southern region of the US and several cardiovascular risk factors, including hypertension, hypertension, diabetes mellitus, and hyperlipidemia were commonly diagnosed (eTables 3 and 4).

Black enrollees were at higher risk for hemorrhagic stroke than whites, with an OR of 1.21 (95% CI, 1.17–1.26) for black men and 1.15 (95% CI, 1.11–1.20) for black women. As with ischemic stroke, the annual rate of first hospitalization for hemorrhagic stroke declined over time for both blacks and whites (p for trends <0.001, Figure 1b). The decline in stroke rate was similar between blacks and whites, with black women experiencing a marginally smaller decline (OR for the interaction between black race and year 1.002 (95% CI 0.999–1.004) for men and 1.003 (95% CI 1.001–1.006) for women).

The 30-day mortality after hospitalization for hemorrhagic stroke was considerably higher than after ischemic stroke. Blacks had lower 30-day stroke mortality than whites (Figure 2). Risk-adjusted hemorrhagic stroke mortality improved over time and more prominently for blacks. Hemorrhagic stroke mortality decreased in black men from 39.1% in 1988 to 27.5% in 2013, and from 46.4% to 40.0% in white men (p value for trends <0.001, OR for interaction term of race by year 0.988 [95% CI, 0.983 – 0.993]). Among women, mortality in black women decreased from 44.4% to 30.9% and from 44.6% to 44.2% for white women (p value for trends <0.001, OR for interaction term of race by year 0.99 [95% CI, 0.985– 0.994]).

Stroke risk factor prevalence and medication use in the general US population

In the general US Medicare population, the prevalence of several risk factors for stroke decreased over time, notably, smoking, mean systolic blood pressure, and mean total cholesterol level (eTables 5 and 6). Other factors, such as diabetes mellitus and obesity, increased in the population over time.

Black men were more likely than white men to be active smokers (p<0.01), although the prevalence of smoking declined over time in both races: 23.2% of black men and 14.3% of white men in 1988–1994 reported smoking, declining to 15.6% of black men and 6.9% of white men by 2011–2014 (eTable 5). Among women, the differences in smoking were not statistically different between blacks and whites (p=0.91, eTable 6).

The mean systolic blood pressure in the population declined over time, for both men and women (eTable 5 and 6). Reductions in blood pressure and cholesterol occurred during a period of time when there occurred dramatic increases in the use of antihypertensive medications and statins in the Medicare population (Figure 3).

In contrast to blood pressure and cholesterol, the population prevalence of diabetes mellitus and obesity (body mass index $\geq 30\ kg/m^2$) increased over time. Black enrollees were more likely than whites to have diabetes or obesity (p<0.01, both). However among women, the proportion of white women with obesity steadily increased, approaching the prevalence of obesity amongst black women (eTable 6).

Discussion

Our study of evolving US trends in stroke found that both black and white Medicare enrollees experienced considerable improvements over time with regard to stroke hospitalizations. Improvements in 30-day mortality after stroke hospitalizations were also observed. Although black men and women continued to be at higher risk for stroke overall, the improvements in stroke hospitalization rates and mortality were comparable for both blacks and whites. In fact, black men and women experienced slightly greater improvements than whites in terms of 30-day mortality for both stroke subtypes.

The higher risk for stroke amongst black Americans is likely multifactorial. Our study, like others, found that the prevalence of individual risk factors for stroke varied by race and that black enrollees had, overall, a higher calculated population-risk for stroke based on stroke

risk factors(24). Diagnosed hypertension at the time of stroke, for example, was significantly more prevalent amongst black men and women compared to whites. There were also several notable improvements in modifiable risk factors that occurred over time. The proportion of people in the general population who reported being a current smoker has fallen for both men and women, blacks and whites. Two additional risk factors that are modifiable – systolic blood pressure and total cholesterol level – have also improved over time. This occurred in conjunction with increased use of antihypertensive medications and statins and it is likely that more widespread use of these medications combined with reductions in smoking use have contributed to these improvements. If so, this represents a significant success in public health and one that has been shared by both races.

Nevertheless there remain areas of concern that may should alert clinicians, policy makers, and researchers on further opportunities to reduce the burden of stroke in the US. Smoking prevalence, for example, although declining continues to be unacceptably high and disproportionately higher amongst black men. Diabetes and overweight/obesity continue to be a worsening epidemic in the US. These conditions, in contrast to high blood pressure and hyperlipidemia, which have more targeted pharmacologic treatments, may require more multifaceted approaches to management including behavioral and lifestyle modifications, in addition to medical therapy.

In addition to differences in the prevalence of comorbid conditions, regional and socioeconomic factors may also contribute to disparities in observed stroke outcomes(11). Other studies have noted that a combination of medical, socioeconomic, and behavioral factors contribute to a disproportionate burden of stroke in the Southern US region, sometimes called the "Stroke Belt"(25).

Our study found that 30-day mortality after stroke hospitalization has improved significantly over time, and was more pronounced among black enrollees than whites. The exact reason for this observation is not clear. Because our study focused on the 65 year old population, we were not able to determine whether differing rates of stroke at younger ages might have contributed to this finding. It is possible that blacks were more likely to have severe strokes at younger ages(26), potentially leading to survivor bias in the population we observed. The shared reduction in stroke-related mortality in both racial categories may also represent improvements in acute stroke care nationwide(27, 28).

Our study had several limitations. The data on stroke hospitalizations and mortality, as well as some of the clinical data, were administrative in nature and restricted to the 65 year old Medicare population. Hence, we could not be sure that the first stroke hospitalization in the MedPAR database actually represented the first stroke for that individual. Although it is likely that the majority of people with incident strokes present to hospitals, if there were systematic differences by race in terms of the age at presentation or likelihood of being hospitalized, our findings could be biased(13, 29). Finally, because we used data from three separate data sources, we were unable to make direct correlations between the stroke rates observed in one data set and changes in risk factors observed in another. We cannot claim that changes in stroke risk factors and medication use had a causal effect on the reductions in

stroke hospitalizations. Regardless, our study illustrates the considerable advances in cardiovascular risk factor modification that have been shared by both blacks and whites.

In conclusion, although black Americans continued to experience higher rates of stroke hospitalizations than whites, there have been considerable improvements in stroke incidence and short-term stroke-related mortality over the past 25 years shared by both black and white Medicare enrollees.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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a. Ischemic Strokes
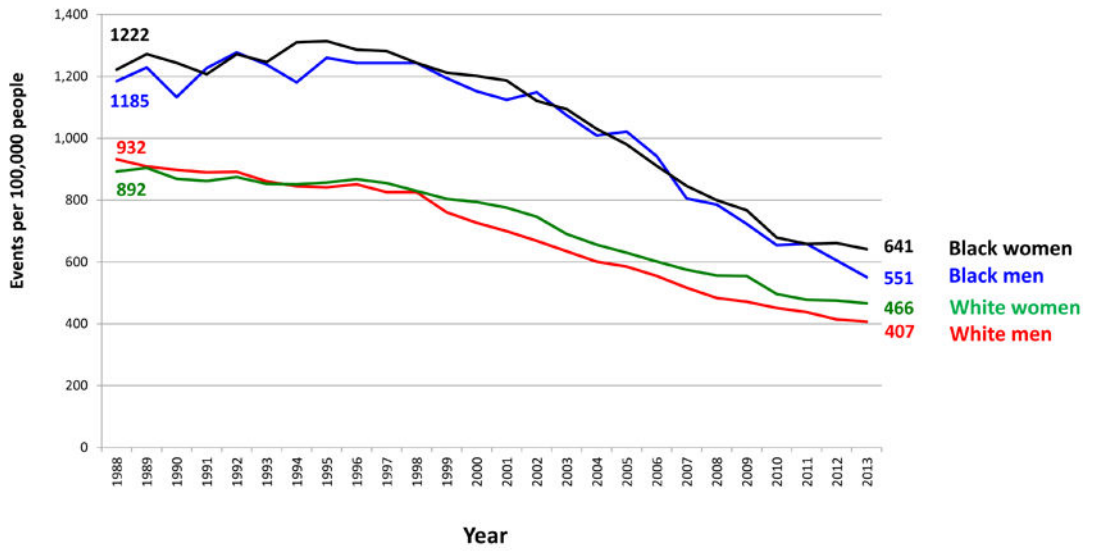
b. Hemorrhagic Strokes
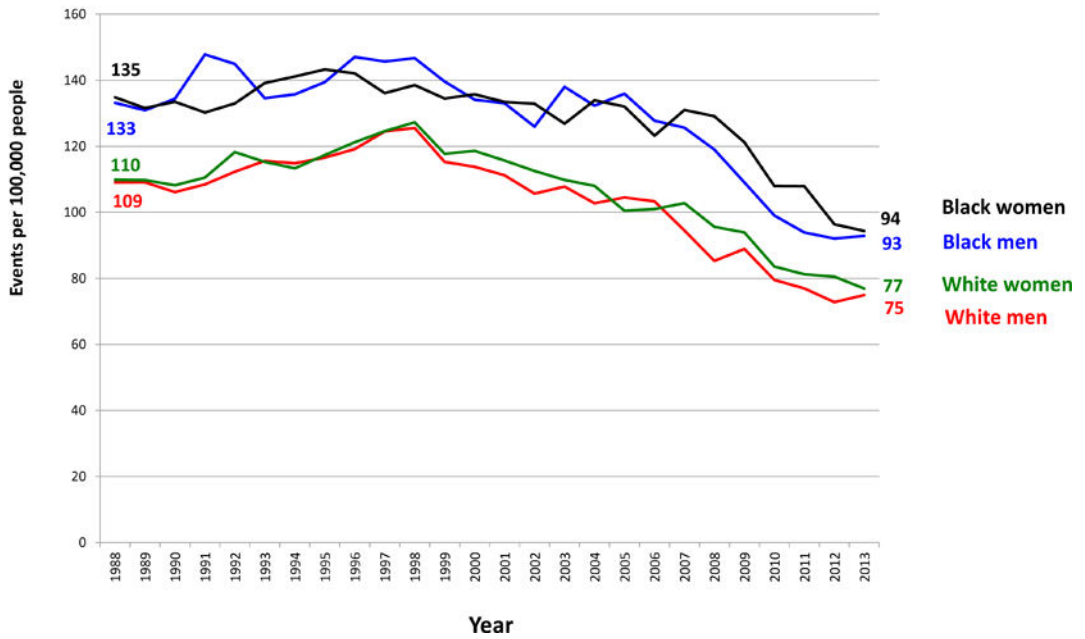
Figure 1.
Age-adjusted Rates of First Hospitalization for (a) Ischemic and (b) Hemorrhagic Stroke in the US Medicare Population aged 65 years, 1988–2013.
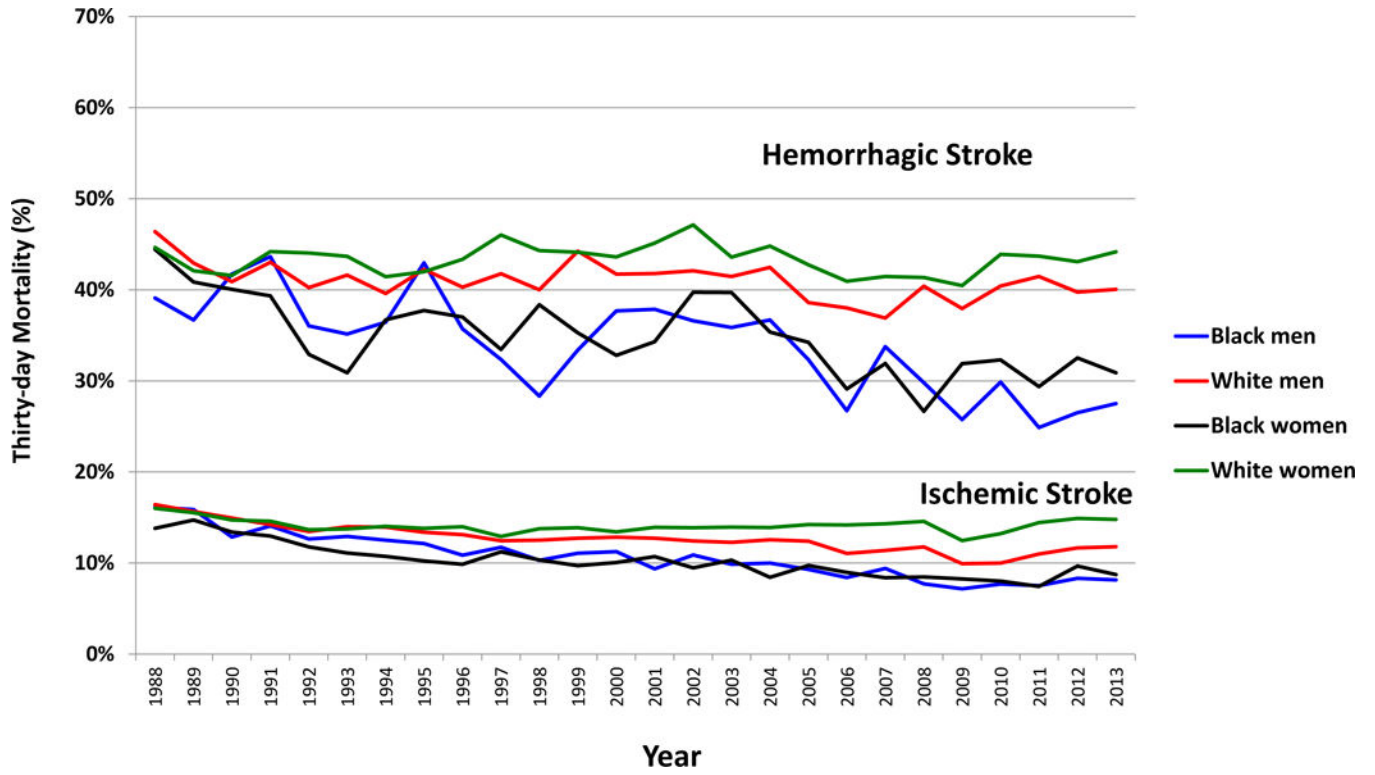
Figure 2.
Risk-adjusted 30-day Mortality after Hospitalization for Ischemic and Hemorrhagic Stroke in the US Medicare Population aged   65 years, 1988–2013.
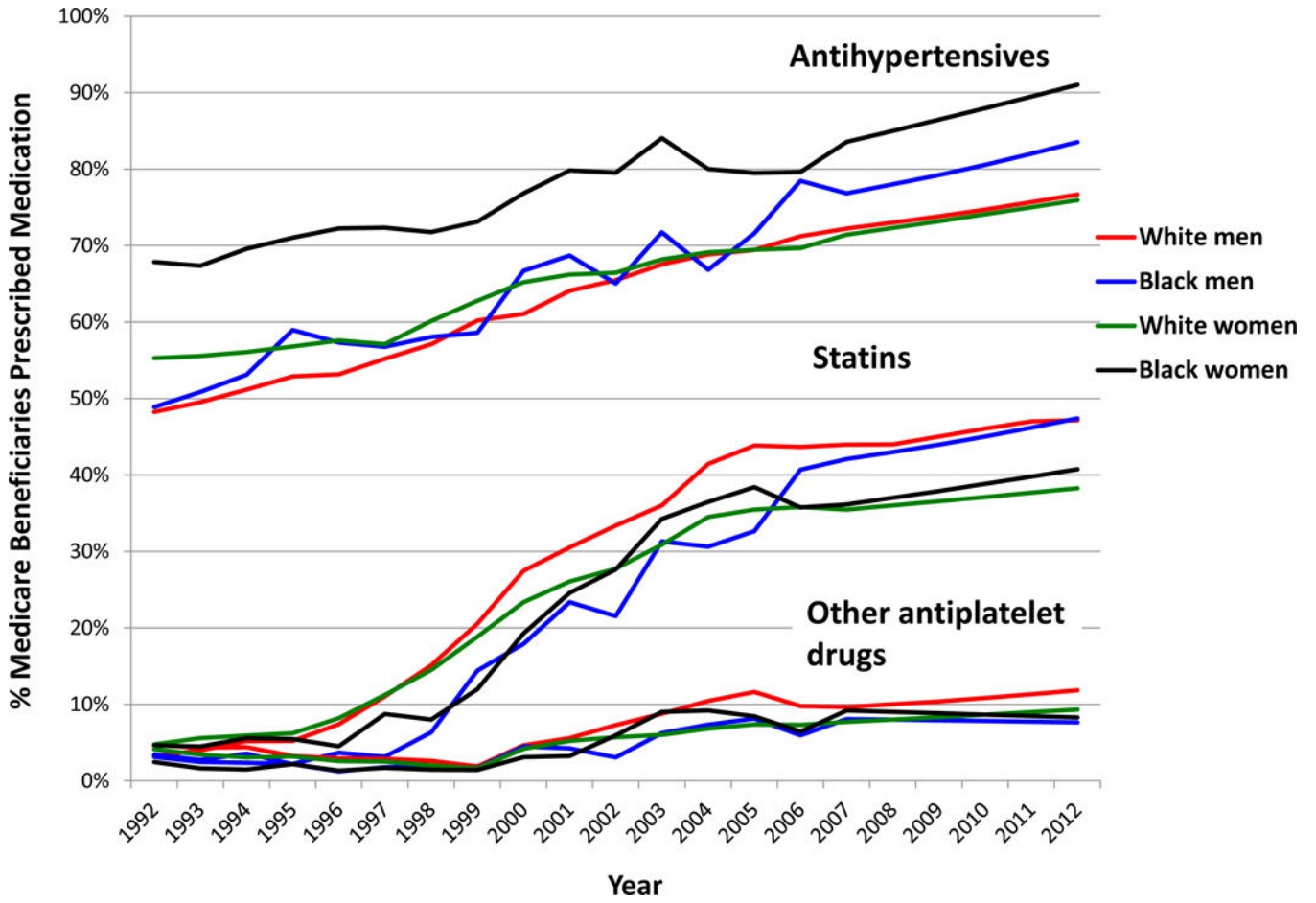
Figure 3.
Prevalence of Antihypertensive Medications, Statins, and Non-aspirin Antiplatelet Drugs
among Medicare Enrollees aged 65 years, 1992–2012.

Table 1.

Age-adjusted hospitalizations per 100,000 people for ischemic and hemorrhagic stroke, 1988–2013

| | Ischemic Strokes per 100,000 | | | | Hemorrhagic Strokes per 100,000 | | | |
| | Men | | Women | | Men | | Women | |
Year	Black	White	Black	White	Black	White	Black	White
1988	1,185	932	1,222	892	133	109	135	110
1989	1,229	909	1,272	904	131	109	132	110
1990	1,133	898	1,244	869	134	106	133	108
1991	1,227	889	1,207	862	148	108	130	111
1992	1,278	892	1,272	875	145	112	133	118
1993	1,238	860	1,247	852	135	116	139	115
1994	1,181	845	1,310	851	136	115	141	113
1995	1,260	842	1,314	857	139	117	143	117
1996	1,243	851	1,287	868	147	119	142	121
1997	1,243	826	1,282	855	146	125	136	125
1998	1,243	826	1,244	829	147	126	139	127
1999	1,194	760	1,212	804	140	115	134	118
2000	1,152	726	1,201	794	134	114	136	119
2001	1,125	699	1,186	775	133	111	133	116
2002	1,148	668	1,121	746	126	106	133	113
2003	1,074	635	1,094	690	138	108	127	110
2004	1,009	601	1,030	656	132	103	134	108
2005	1,021	585	980	629	136	104	132	101
2006	942	555	911	601	128	103	123	101
2007	806	517	846	575	126	94	131	103
2008	785	483	799	556	119	85	129	96
2009	723	471	767	555	109	89	121	94
2010	654	451	679	496	99	80	108	84
2011	659	437	658	478	94	77	108	81
2012	605	414	661	475	92	73	96	81

	Ischemic Strokes per 100,000				Hemorrhagic Strokes per 100,000			
	Men		Women		Men		Women	
Year	Black	White	Black	White	Black	White	Black	White
2013	551	407	641	466	93	75	94	77

Table 2.

Risk-adjusted 30-day mortality after ischemic and hemorrhagic stroke hospitalizations, 1988–2013

| Year | Ischemic Stroke Mortality | | | | Hemorrhagic Stroke Mortality | | | |
| | Men | | Women | | Men | | Women | |
	Black	White	Black	White	Black	White	Black	White
1988	16%	16%	14%	16%	39%	46%	44%	45%
1989	16%	16%	15%	16%	37%	43%	41%	42%
1990	13%	15%	13%	15%	42%	41%	40%	42%
1991	14%	14%	13%	15%	44%	43%	39%	44%
1992	13%	13%	12%	14%	36%	40%	33%	44%
1993	13%	14%	11%	14%	35%	42%	31%	44%
1994	12%	14%	11%	14%	36%	40%	37%	41%
1995	12%	13%	10%	14%	43%	42%	38%	42%
1996	11%	13%	10%	14%	36%	40%	37%	43%
1997	12%	12%	11%	13%	32%	42%	33%	46%
1998	10%	13%	10%	14%	28%	40%	38%	44%
1999	11%	13%	10%	14%	33%	44%	35%	44%
2000	11%	13%	10%	13%	38%	42%	33%	44%
2001	9%	13%	11%	14%	38%	42%	34%	45%
2002	11%	12%	9%	14%	37%	42%	40%	47%
2003	10%	12%	10%	14%	36%	41%	40%	44%
2004	10%	13%	8%	14%	37%	42%	35%	45%
2005	9%	12%	10%	14%	32%	39%	34%	43%
2006	8%	11%	9%	14%	27%	38%	29%	41%
2007	9%	11%	8%	14%	34%	37%	32%	41%
2008	8%	12%	8%	15%	30%	40%	27%	41%
2009	7%	10%	8%	12%	26%	38%	32%	40%
2010	8%	10%	8%	13%	30%	40%	32%	44%
2011	8%	11%	7%	14%	25%	41%	29%	44%
2012	8%	12%	10%	15%	26%	40%	33%	43%

| | Ischemic Stroke Mortality | | | | Hemorrhagic Stroke Mortality | | | |
| | Men | | Women | | Men | | Women | |
Year	Black	White	Black	White	Black	White	Black	White
2013	8%	12%	9%	15%	27%	40%	31%	44%