

Racial Differences in Hospital Death for Atrial Fibrillation: The National Inpatient Sample 2001-2012

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ABSTRACT

Background

Understanding racial differences in outcomes for atrial fibrillation (AF) may guide interventions to diminish health inequities.

Methods and Results

In a retrospective, cross-sectional study of adults hospitalized with a principal diagnosis of AF using the 2001-2012 National Inpatient Sample, we assessed racial differences for in-hospital. We accounted for case-mix and clustering by race within hospitals to estimate odds ratios (OR) for death associated with individual patient race and hospital racial composition. We identified 676,567 hospitalizations (mean age 71.8 years, 53.6% women) with principal diagnosis of AF (84.2% White, 7.1% Black, 5.0% Hispanic). Black (vs. White) race was associated with 1.63-fold (95% CI, 1.50-1.78) risk of death. Other races had similar risk of death as Whites. Risk of death for Blacks (vs. Whites) declined over time [2001: OR 1.78(95% CI 1.31-2.43); 2012: OR 1.23(95% CI 0.92-1.64)]. Racial differences in deaths within hospitals narrowed, while hospitals with larger proportions of Blacks had persistently worse outcomes than hospitals with fewer Blacks (OR 1.08 per 10% increase in Blacks in 2001 and 2012).

Conclusion

Black patients with a principal diagnosis of AF were more likely to suffer in-hospital death than Whites. Our findings suggest racial disparities based upon individual patients' race improved over time, but outcomes were persistently worse at hospitals with higher proportions of Black patients, regardless of patients' races.

KEYWORDS: Atrial fibrillation, Disparities, Outcomes, Race

ABBREVIATIONS: AF: Atrial Fibrillation; HF: Heart Failure; ICD-9-CM: International Classification of Diseases Ninth Revision, Clinical Modification; NIS: Nationwide Inpatient Sample

INTRODUCTION

Atrial fibrillation and atrial flutter (simplified here as AF) affects about 1-3% of adults and causes significant morbidity [1-4]. Prior studies have identified multiple racial differences in AF epidemiology, treatment, and outcomes. Among the elderly or in regional populations, Blacks with AF received stroke prevention or AF-related treatment less often than non-Hispanic Whites (hereafter “Whites”) [5-7] and were more likely to have AF-associated strokes and heart failure (HF) [8-10]. A nationally representative 2-year cross-sectional study showed Black patients hospitalized with AF were more likely to die in the hospital than Whites and less likely to receive catheter ablation [11]. Although racial differences for AF are reported in prior studies of limited geographic, temporal, or age distribution, population-based estimates and temporal trends are unclear. In addition, racial inequities may be related to different treatments delivered based upon the race of an individual patient (from conscious or unconscious bias) or may arise from lower quality of care at hospitals that serve a large proportion of racial minorities. How racial differences for AF relate to variation in outcomes within and across hospitals have not been well-characterized [12-14]. We investigated racial differences in AF-associated procedures and adverse outcomes during more than a decade (2001-2012) using a nationally representative sample of US hospitalizations. Further, we determined racial differences in AF care related to individual patient race as well as hospital-level differences in racial composition.

MATERIAL AND METHODS

We used data from the US National Inpatient Sample and the Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality to identify hospitalizations with a principal diagnosis of AF or atrial flutter (International Classification of Diseases Ninth Revision, Clinical Modification, ICD-9-CM, 427.3) during years 2001-2012. As ICD-9-CM does not distinguish between AF or atrial flutter, we will simplify in this paper and refer to both as AF. Prior studies of claims have shown up to 95% sensitivity, 99% specificity, and 70-96% positive predictive value for AF ICD-9-CM 427.3×.[15-17] The NIS has been used extensively to characterize US healthcare utilization [18]. In brief, NIS approximates a 20% stratified sample of non-federal acute care hospitals that are representative of US hospitalizations-including both inpatient and observation status [18].

We excluded hospitalizations for patients age <40years, race categorized as “other” (2.3%) or not documented, or missing essential covariates or hospital data (age, sex, race, admission date, discharge date, or date of in-hospital death) (Table A 1 in the supplementary appendix). We also excluded patients with same-day admission and discharge and length of stay >30 days to avoid bias by patients who are either relatively well or overly complex, respectively. We excluded hospitalizations associated with cardiothoracic surgery or coronary interventions as primary procedures. We assessed racial differences in hospitalization rates for AF. We calculated annual age-adjusted AF hospitalization rates by race using NIS hospital weighting and US census data [19].

Our primary objective was to whether there were racial differences in in-hospital AF procedures and coincident clinical outcomes over a 12-year period. Race and ethnicity were provided by the hospital sources to the NIS datasets. If Hispanic ethnicity was reported by the hospital source, the patient’s race/ethnicity category was defined as Hispanic. Associated cardiovascular conditions included HF and ischemic stroke, and the primary outcome was in-hospital death. Procedures included surgical and catheter ablation, and cardio version. We defined outcomes and procedures by ICD-9-CM codes consistent with prior use and detailed in Table A 2 of the supplementary appendix [5,11,20]. Patients of White race were the referents. Models were adjusted for covariates including age, sex, calendar year, comorbid conditions[myocardial infarction (MI), hypertension, diabetes mellitus [21], dementia, chronic obstructive pulmonary disease, chronic liver disease, and chronic kidney disease using enhanced Charlson and Elixhauser ICD-9-CM codes, [22] Table A 2, hospital characteristics (region, location as urban vs. rural, and teaching status), and primary payer (Medicare, Medicaid, private, self-pay). Diagnoses analyzed were limited to the principal diagnosis and the first 14 secondary diagnoses to maintain consistency across the available data within the NIS from 2001-2012. Continuous variables were reported as means and tested using the F test and categorical variables as proportions and tested using the chi-square test.

Associations between race and clinical outcomes or AF procedures were estimated using generalized estimated equations with standard errors accounting for hospital clustering. Temporal trends were assessed with interaction terms for race and year (continuous; race*year). We used a previously described decomposition method to separate racial differences into ‘within-hospital’ and ‘across-hospital’ effects [23,24]. Within-hospital effects were estimates of the difference in outcomes associated with an individual patient’s race after adjusting for each hospital’s overall racial composition. Across-hospital

effects were estimates of outcome differences associated with each hospital’s racial composition after adjusting for an individual patient’s race. Across-hospital associations were primarily determined for every 10% increase in the proportion of Black patients across patients hospitalized at a given center. We also determined across-hospital associations for a theoretical 100% change in the proportion of Black patients across hospitals for comparison with the adjusted effect of race as a binary (Black vs. White) variable on death (supplement). We compared within- and across-hospital estimates in 2001 and 2012 to study temporal trends among Blacks compared with Whites.

All analyses were conducted using SAS version 9.4 (Cary, NC), and a two-sided alpha of ≤ 0.05 was deemed statistically significant. The Institutional Review Board at Boston University Medical Center deemed the study as not human subject’s research.

RESULTS

A total of 676, 567 hospitalizations (population-based estimate of 3,329,124) with a principal diagnosis of AF were identified from 2001-2012. Table 1 shows patient characteristics by race. The mean age was 71.8 years and women comprised 53.6% of the sample. The patients with AF were 84.2% White, 7.1% Black, and 5.0% Hispanic, and 1.4% Asian/Pacific Islander. Compared with Whites, patients of other racial groups were more likely to have Medicaid or self-pay for care, and thus have lower socioeconomic status.

CHARACTERISTICS	White	Black	Hispanic	Asian/PI	All races	P value
N (unweighted)	569669	48036	33828	9472	676567	
N (weighted)	2803629	235762	166609	45157	3329124	
% of weighted participants	84.20%	7.10%	5.00%	1.40%	100%	
Age, mean years	72.4	66.5	69	70.7	71.8	<0.001
Women, %	53.5	55	53.9	52.8	53.6	<0.001
Hospital location: urban, %	83.9	90.9	93.4	93.7	85	<0.001
Teaching hospital, %	36.9	56.2	43.9	46.2	38.9	<0.001
Payer						<0.001
Medicare, %	71.1	59.4	56.8	56.9	69.1	
Medicaid, %	2.3	10.2	12.7	12.5	3.7	
Private, %	23	22	20.2	24.2	22.8	
Self-pay, %	1.9	5.2	6.2	3.7	2.5	
No charge, %	0.2	0.7	1.2	0.3	0.3	
Other, %	1.5	2.5	2.8	2.4	1.7	
CO-MORBIDITIES						
Diabetes, %	21.2	32.7	32.9	29.1	22.8	<0.001
Hypertension, %	65.2	78.6	71	70.5	66.6	<0.001
ACS, %	31.5	27.1	29.5	27.2	31	<0.001
History of MI, %	30.9	26.8	28.6	26.3	30.4	<0.001
Dyslipidemia, %	37	30.1	33.2	37	36.3	<0.001
Dementia, %	0.8	1	0.8	1	0.8	<0.001
COPD, %	4	2.8	2.5	2.2	3.8	<0.001
CKD, %	7.4	16.4	9.3	11	8.2	<0.001
CLD, %	0.9	1.2	2	1	1	<0.001

Table 1: Characteristics and co-morbidities for admissions with a primary diagnosis of AF from 2001-2012

Estimated hospitalization rates increased for all races over the study period. Whites had the highest population-based AF hospitalization rate ranging from 186.1-298.5 per 100,000 US residents during the years 2001-2012 (Figure 1 and Table A 4). AF hospitalization rates were lower for Blacks (range 91.3-187.3 per 100,000) and Hispanics (range 87.3-124.2 per 100,000). Asians/PI (range 49.6-83.7 per 100,000) had the lowest hospitalization rates.

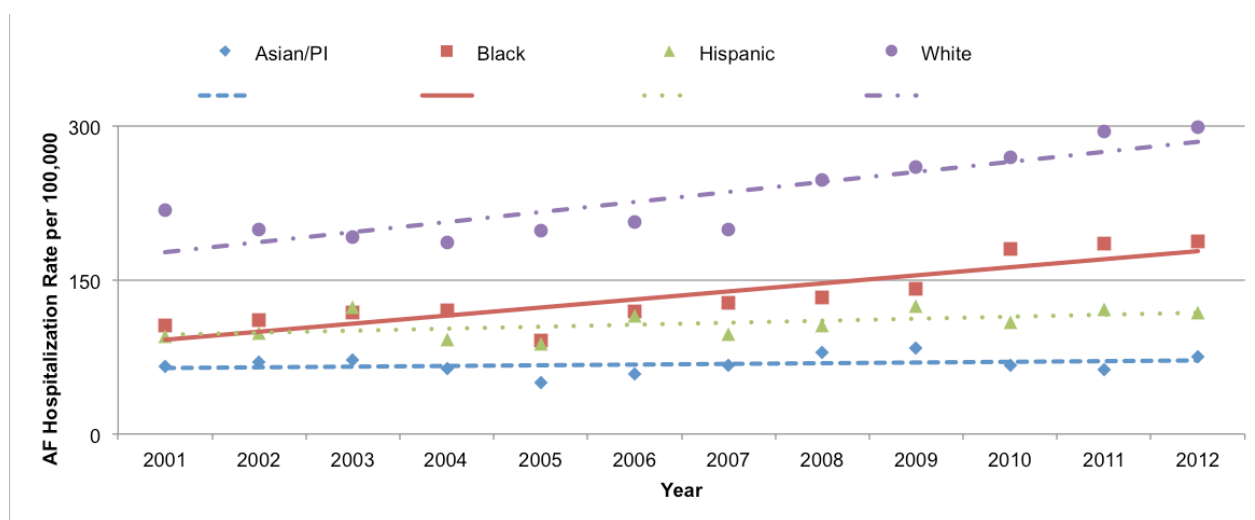


Figure 1: Rate of Primary Hospitalization for AF per 100,000 US adults (>40 years old) by year and race, NIS 2001-2012.

In unadjusted analysis (Table 2), HF was the most common outcome – occurring in 26.9% of all participants. HF was more prevalent among Blacks (35.1%) than Whites (26.2%). Death occurred in 1.0% of all participants and was also more common among Blacks (1.4%) than Whites (1.0%). Cardio version was the most common procedure for AF and occurred in 14.3% of all hospitalizations. Cardio version was less frequent among Blacks (10.5%) than Whites (15.0%).

OUTCOMES: Unadjusted	White	Black	Hispanic	Asian/PI	All races
HF, %	26.2	35.1	27.6	23.7	26.9
Stroke, %	1.8	1.2	1.4	1.3	1.7
Died, %	1.0	1.4	1.0	0.9	1.0
PROCEDURES: Unadjusted					
Catheter ablation, %	0.3	0.3	0.3	0.2	0.3
Surgical ablation, %	0.0	0.0	0.0	0.0	0.0
Cardioversion, %	15.0	10.5	9.4	9.2	14.3
Any AF procedure [¶] , %	15.3	10.8	9.6	9.4	14.6

Table 2: Outcomes and procedures by race for admissions with a primary diagnosis of AF from 2001-2012

[¶] Catheter ablation, surgical ablation, or cardioversion

Blacks [OR 1.67 (95% CI 1.63-1.71)] and Hispanics [OR 1.11 (95% CI 1.09-1.15)] hospitalized for AF had greater odds of comorbid HF compared with Whites across the 2001-2012 year span after adjustment (Table 3, Figure A 1). In contrast, Asians/Pacific Islanders had lower comorbid HF [OR 0.87(95% CI, 0.82-0.91)] than Whites. Stroke was less common in all studied racial groups compared with Whites after adjustment: Blacks [OR0.79 (95% CI, 0.72-0.86)], Hispanics [OR0.83 (95% CI 0.75-0.91)], and Asian/Pacific Islander [OR 0.72(95% CI 0.59-0.86)].

Blacks with AF had 1.63-fold (95% CI 1.50-1.78; unadjusted mortality rate 1.4% vs. 1.0 %) higher risk of in-hospital mortality than Whites after multivariable adjustment (Table 3). Compared with Whites, mortality was similar for Hispanics [OR 1.09(95% CI 0.97-1.23)], and Asians/PI [OR1.07 (95% CI 0.86-1.31)]. The risk of death for Blacks compared to White patients decreased over time (p for interaction<.0001); by year 2012, significant outcome differences based upon race were no longer identified (Figures 2[unadjusted] and 3 [adjusted], Table A 5).

Ablation and cardio version were less common among people of all studied ethnic/racial groups compared with Whites. Blacks [OR 0.54 (95% CI 0.53-0.56)], Hispanics [OR 0.52 (95% CI 0.50-0.54)]; and Asian/Pacific Islanders [OR 0.51 (95%

CI 0.47-0.55)] were less likely to receive AF procedures (Table 3).

	White	Black	Hispanic	Asian/PI
OUTCOMES: Adjusted OR (95% CI)				
HF#	ref	1.67*† (1.63, 1.71)	1.11*† (1.09, 1.15)	0.87*† (0.82, 0.91)
Stroke#	ref	0.79* (0.72, 0.86)	0.83* (0.75, 0.91)	0.72* (0.59, 0.86)
Death	ref	1.63*† (1.50, 1.78)	1.09 (0.97, 1.23)	1.07 (0.86, 1.32)
PROCEDURES: Adjusted OR (95% CI)				
Catheter ablation	ref	0.78* (0.66, 0.92)	0.66* (0.53, 0.81)	0.46*† (0.29, 0.72)
Cardioversion	ref	0.54*† (0.52, 0.56)	0.52*† (0.50, 0.54)	0.51* (0.48, 0.55)
Any AF procedure†	ref	0.54*† (0.53, 0.56)	0.52*† (0.50, 0.54)	0.51* (0.47, 0.55)

Table 3: Adjusted association between race and outcomes or procedures for admissions with a primary diagnosis of AF from 2001-2012

#HF outcome adjusted for stroke. Stroke outcome adjusted for HF. Death outcome adjusted for both HF and stroke.

* P<.05, † Interaction between race and year‡ Catheter ablation, surgical ablation, or cardioversion

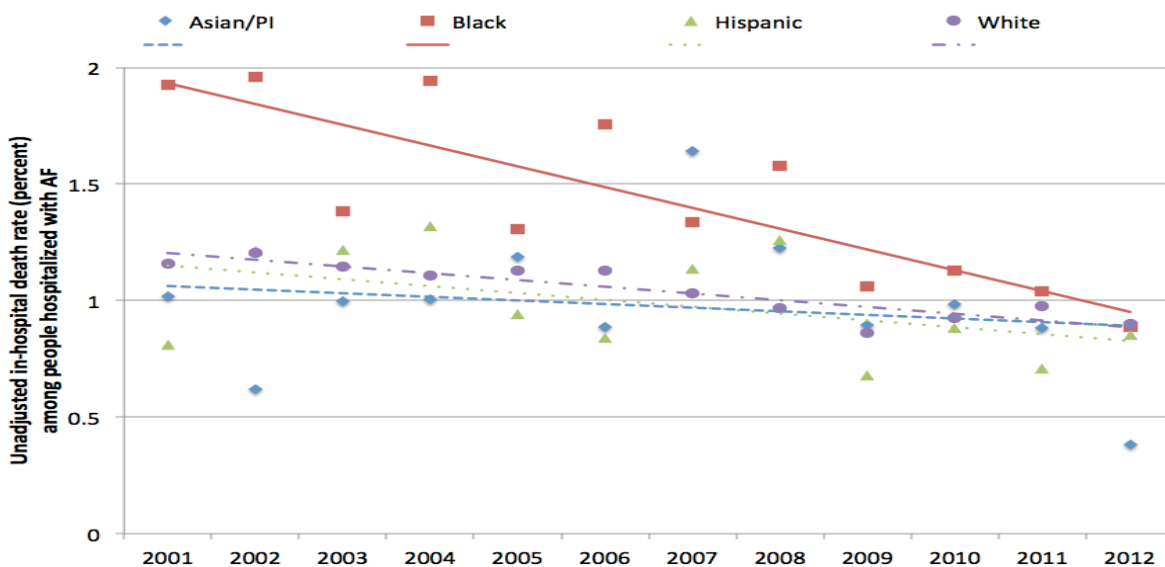


Figure 2: Unadjusted death, by race and year, NIS 2001-2012. Unadjusted percent of deaths among people hospitalized principally for AF. Linear trend lines by race are shown.

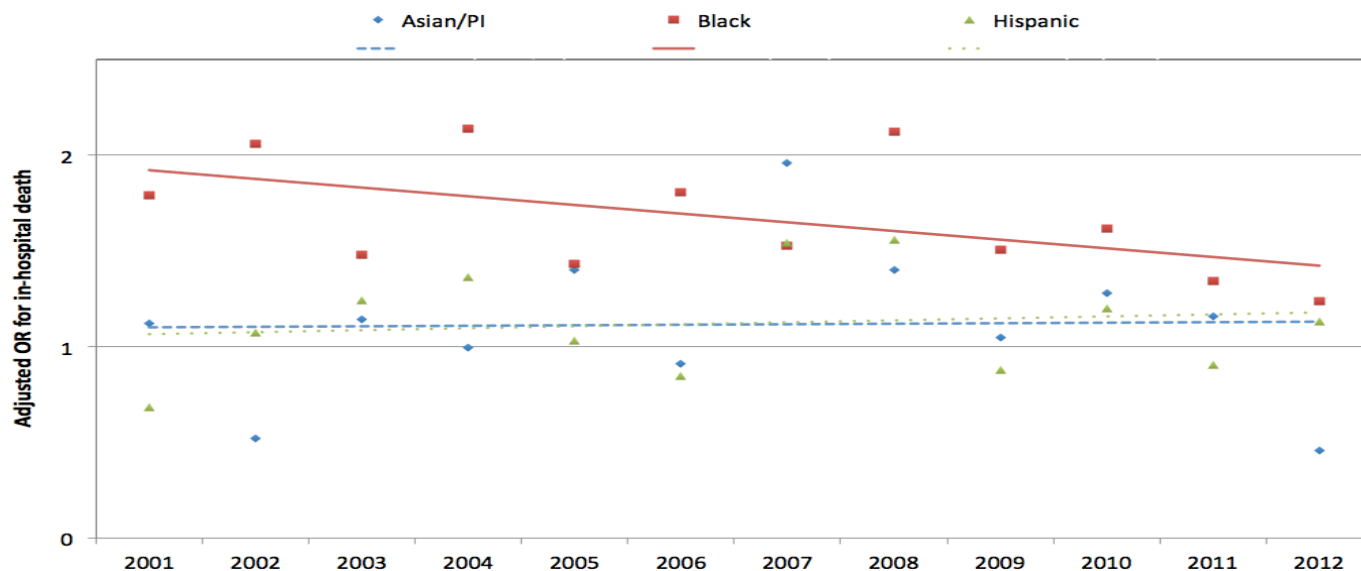


Figure 3: Adjusted odds ratios for death by race and year among people hospitalized principally for AF. Adjusted for age, sex, comorbidities (diabetes, hypertension, history of myocardial infarction, Dyslipidemia, chronic obstructive pulmonary disease, chronic kidney disease, chronic liver disease, heart failure, and stroke), hospital location, hospital teaching status, payer and region, White = referent. Linear trend lines by race are shown. There are interactions between race and year for Blacks.

Our decomposition analysis primarily evaluated the within- and across-center association of a 10% increase in the proportion of patients at a hospital who were Black (Table 4). Both within-center [OR1.06 (95% CI 1.02-1.09)] and across-center [OR1.08 (95% CI 1.00-1.16)] differences contributed to higher deaths for Blacks compared with Whites in 2001. In 2012 the within-center difference was no longer significant [OR 1.01 (95% CI 0.97-1.04)]; however, the across-center difference persisted [OR1.08 (95% CI 1.01-1.14)]. We also modeled the predicted death between theoretical hospitals with 0% vs. 100% proportion of patients of Black race (Table A 6): within-center association between Black vs. White race and death was reduced [2001: OR 1.71 (95% CI 1.21, 2.41); 2012 OR 1.05 (95% CI 0.74, 1.49)], while the across-center difference persisted [2001: OR 2.06 (95% CI 0.98, 4.32); 2012 OR 2.06 (95% CI 1.16, 3.70)].

	Procedures		Death	
	2001	2012	2001	2012
Adjusted for covariates (presence or absence of Black race vs. White)				
Combined across- and within-center	0.55 (0.48, 0.62)	0.54 (0.50, 0.59)	1.78 (1.31, 2.43)	1.23 (0.92, 1.64)
Adjusted for covariates and confounding by center (10% increase in the proportion of patients hospitalized who are black)				
Within-center (similar racial mix)	0.95 (0.93, 0.96)	0.94 (0.93, 0.95)	1.06 (1.02, 1.09)	1.01 (0.97, 1.04)
Across-center (differing racial mix)	0.93 (0.87, 0.99)	0.94 (0.90, 0.99)	1.08 (1.00, 1.16)	1.08 (1.01, 1.14)

Table 4: Associations between black race, and in-hospital death and procedures adjusting for center confounding for patients hospitalized primarily for AF in NIS 2001 and 2012. OR (95% CI) Referent = White

There were persistent contributions to fewer AF-associated procedures for Blacks compared with Whites for both within-center [2001: OR 0.95(95% CI 0.93, 0.96); 2012: OR 0.94 (95% CI 0.93, 0.95)] and across-center differences [2001: OR 0.93(95% CI 0.87, 0.99); 2012: OR 0.94 (95% CI, 0.90, 0.99)] (Table 4). Models for the predicted procedures between theoretical hospitals with 0% vs. 100% proportion of patients of Black race are shown in Table A 6.

DISCUSSION

We investigated racial differences in outcomes and procedures associated with hospitalization for AF from 2001-2012 in the US. The persistently lower rates of AF hospitalization for Blacks is consistent with studies of community-based cohorts and Medicare beneficiaries [17,25]. Blacks with AF were approximately 60% more likely to experience in-hospital mortality and 50% less likely to undergo AF-associated procedures compared with Whites. Reassuringly, racial differences for in-hospital mortality declined over time, and no longer significantly varied in 2012. Importantly, differences in AF treatment based upon an individual patient's race were more equitable over time within centers. However, hospitals caring for more Black patients continued to show worse mortality among patients hospitalized for AF regardless of the individual patient's race.

In the United States, people of racial and ethnic minority groups have different patterns of AF care and management than Whites. Our findings are consistent with studies identifying racial differences in Blacks with AF and other cardiovascular diseases. Blacks and Hispanics on average have strokes at younger ages and have greater disability and mortality than Whites [26,27]. In older adults, Medicare data indicate that compared with Whites, Blacks and Hispanics with AF have increased risk of stroke (1.2- to 1.7-fold) and death (1.1- to 1.5-fold) [28]. The finding in our study of fewer strokes among patients who are members of racial minority groups compared with Whites may be related to our focus on patients with a primary hospitalization diagnosis of AF, our study's inclusion of both prevalent and incident AF, and survival bias within readmitted patients [29].

Optimistically, the racial difference in death between Blacks and Whites appears to be narrowing over a contemporary decade. The within-center component of death narrowed whereas the across-center component persisted. The changing pattern suggests that care within individual hospitals is becoming more equitable. However, Blacks may have continued to have higher death rates because they were more likely to be admitted to poorer performing hospitals, rather than differences in care provided to individuals based upon their race. Prior analyses similarly showed that Blacks, in general, present to poorer performing hospitals after acute MI [12,30]. Further, compared with Whites, Black patients tend to live closer to higher-quality hospitals but are more likely to receive cardiac surgery at lower-quality hospitals [31]. Black patients may feel unwelcome at hospitals which treat predominantly White patients [31]. In making health decisions, racial concordance between physician and patient has been found to be more important for Blacks than Whites [32,33]. Consistent with prior studies, we found that the likelihood of AF procedures was persistently about half that among racial minorities compared with Whites - both across and within hospitals.^{7,11} Implicit racial stereotypes by providers, patient socioeconomic status, or variation in clinic severity may affect decision-making either subconsciously or overtly [34].

Broad efforts focusing on quality improvement and elimination of disparities, such as those promoted through the Patient Protection and Affordable Care Act of 2010 may provide the impulse to affect meaningful change [35]. Thus, more comprehensive, longitudinal, and contemporary data are needed to assess the current disparities in the context of healthcare systems rapidly adapting at the community, primary care, and hospital levels.

STRENGTHS AND LIMITATIONS

The analysis using NIS datasets is large, nationally representative, multi-ethnic, contemporary, and allows the assessment of time-trends over a 12-year span. Given the nature of the dataset, there are important limitations.

Principally, the NIS data are limited to hospitalization diagnoses and only prevalent comorbid conditions can be assessed. Clinically relevant comorbidities that developed prior to the hospitalization, including those known to be associated with high risk of stroke and mortality such as those in the CHA₂DS₂-VASc risk prediction rule [36], are not available in the NIS. Second, the data are not longitudinal; we cannot differentiate prevalent from incident AF. Thus, we cannot account for repeated observations, within-patient correlated data, or survival bias. Third, assessment of post-discharge outcomes and causal relationships is limited. Fourth, the data are biased towards sick individuals with multiple hospitalizations. Fifth, the type of AF, prevalence of unrecognized AF, and the decision to hospitalize for AF may vary by race. Sixth, the administrative data available were collected for billing purposes and not clinical care or research [37]. The ICD-9-CM codes used in our study relied on healthcare provider identification and documentation. The assignment of principal diagnosis may reflect reimbursement policies and not clinical importance. Over time, principal diagnosis coding has shifted towards higher reimbursing diagnosis related groups (such as stroke) thus introducing bias.²⁹ In some cases when a patient presents with several acute conditions simultaneously, the diagnosis that has greater reimbursement may be listed in the principal position. Seventh, there is likely residual confounding as administrative data were used for risk adjustment. Particularly, measures of socioeconomic status (including occupation and education), health literacy, medications - including anticoagulation therapy - or clinical prognostic measures, such as vital signs and diagnostic test results, were not available. We used coded secondary diagnoses as surrogates for clinical complexity; however ICD-9 codes do not communicate the severity of comorbidities [38]. Eighth, the NIS samples different hospitals each year and we are not able to adjust for individual hospitals in the analysis. However, the decomposition method allows adjustment for clustering based on the

proportion of black patients at a hospital.

IMPLICATIONS

Blacks hospitalized principally for AF were more likely to die and less likely to receive an AF-associated procedure during hospitalization compared with Whites across a dozen years in a contemporary nationally representative sample of adult hospitalizations. Over time, racial differences for in-hospital mortality declined. Within-center differences based on an individual patient's race have narrowed. However, our findings suggest that Blacks are more likely to be admitted to poorer-performing hospitals. Further public health investigation is warranted to examine the causes for differences in outcomes among Blacks with AF and identify modifiable factors to inform outcome-improving strategies for Blacks with AF.

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SUPPLEMENTARY APPENDIX

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Table A6	Associations between black race, and in-hospital death and procedures adjusting for center confounding for patients hospitalized primarily for AF in NIS 2001 and 2012. Models comparing predicted outcomes of a theoretical hospital with 0% vs. 100% proportion of patients signifying black race

Supplement Methods

The United States National Inpatient Sample and the Nationwide Inpatient Sample (NIS) is a sample of discharges and hospitals from across the US. Survey weights provided by the NIS were incorporated using the SAS 9.4 surveyfreq, surveymeans, and surveyreg procedures to generate nationwide estimates.¹ We estimated mean hospital length of stay by race.

Supplement Results

Outcomes of patients with a primary diagnosis of AF by year from 2001-2012 are shown in the Figure A1 and detailed in Table A 3. Across all studied years, Blacks consistently had a longer mean LOS (range 3.9-4.6 days) than Whites (range, 3.3-3.6 days), Hispanics (range, 3.5-3.9 days), and Asians/PI (range, 3.2-3.8 days).

Table A 1 :Inclusion and Exclusion

Characteristic	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
Discharges in NIS, unweighted	7,452,727	7,853,982	7,977,728	8,004,571	7,995,048	8,074,825	8,043,415	8,158,381	7,810,762	7,800,441	8,023,590	7,296,968	94,492,438
Inclusion criteria													
Any diagnosis of AF	581,418	617,489	639,370	643,732	675,958	707,299	693,861	718,475	710,365	719,828	820,352	746,815	8,274,962
Exclusion criteria													
Age <40 years	5,622	6,061	6,684	6,451	6,685	7,157	7,129	7,435	7,475	7,555	8,213	7,340	83,807
LOS =0 or LOS >30 days	18,232	18,145	18,543	19,432	18,993	20,097	18,713	17,012	17,022	17,395	19,642	16,861	220,087
AF during cardiothoracic surgery	77,237	80,548	82,817	76,906	74,862	72,327	64,621	68,718	69,988	60,103	68,257	61,202	857,586
Missing covariates*	120,960	149,324	142,685	137,124	147,557	154,665	162,290	121,020	98,283	82,316	80,123	34,802	1,431,149
AF not primary diagnosis	311,782	317,557	342,086	358,455	381,307	402,353	391,880	442,876	454,021	485,097	567,648	550,704	5,005,766
Final Analytic Cohort (unweighted)	47,585	45,854	46,555	45,364	46,554	50,700	49,228	61,414	63,576	67,362	76,469	75,906	676,567
Final Analytic Cohort (weighted)	235,763	222,898	222,805	217,700	227,972	248,246	243,652	302,004	322,996	336,599	368,960	379,530	3,329,124

*Covariates includes age, sex, race, length of stay, death status, primary payer, teaching hospital, hospital location
AF, atrial fibrillation; LOS, length of stay; NIS, National Inpatient Sample

Table A 2: Diagnostic and procedural codes used

Diagnosis	ICD-9-CM* code
Atrial fibrillation	427.3
Acute myocardial infarction	410
Acute ischemic stroke	433, 434, 435.8, 435.9, 436
Chronic kidney disease	585
Chronic liver disease	571
Congestive heart failure	402.01, 402.11, 402.91, 404.01, 404.03, 404.13, 404.91, 404.93, 428
Chronic obstructive pulmonary disease	491, 492
Dementia	290
Diabetes	250
Dyslipidemia	272.0, 272.1, 272.2, 272.4
History of myocardial infarction	412, 414.0, 414.2, 414.8, 414.9
Hypertension	401, 402, 403, 404, 405
Procedure	ICD-9-CM* code
Operations On Valves And Septa Of Heart	35.x
Operations On Vessels Of Heart	36.x
Other Operations On Heart And Pericardium	37.x
Catheter ablation	37.34
Surgical ablation	37.33
Cardioversion	99.61 (atrial cardioversion), 99.62 (other electric countershock of heart), 99.69 (Other conversion of cardiac rhythm).
* ICD-9-CM, International Classification of Diseases Ninth Revision, Clinical Modification	

Table A 3: Characteristics, co-morbidities, and unadjusted outcomes for admissions with a primary diagnosis of AF from 2001-2012

CHARACTERISTICS	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
N (unweighted)	47585	45854	46555	45364	46554	50700	49228	61414	63576	67362	76469	75906	676567
N (weighted)	235763	222898	222805	217700	227972	248246	243652	302004	322996	336599	368960	379530	3329124
Age, mean	71.9	71.7	71.5	71.8	71.6	71.6	71.5	71.9	71.9	71.8	72.1	71.5	71.8
Women, %	54.4	54.7	54.4	54.4	53.4	53	53.2	53.4	53.6	53.3	53.9	52.4	53.6
Race: White, %	87.9	86	83.7	84.4	86.8	84	83.1	83.9	83.1	83.4	83.7	83	84.2
Black, %	5.7	6.4	7.1	7.5	5.6	6.9	7.6	6.6	6.6	8.2	7.8	7.9	7.1
Hispanic, %	3.8	4.5	5.9	4.7	4.5	5.8	5.2	4.8	5.5	4.9	5.2	5.1	5
Asian/PI, %	1.2	1.4	1.5	1.4	1.1	1.3	1.5	1.5	1.6	1.3	1.1	1.4	1.4
Other, %	1.5	1.7	1.8	1.9	1.9	2.1	2.6	3.3	3.3	2.3	2.2	2.7	2.3
Hospital location:urban, %	83.4	83.8	83.3	84	85.5	85.2	85.9	84.8	86.3	84.8	85.6	85.8	85
Teaching hospital, %	36	35.6	36.7	36.2	34.1	42.2	40.2	38.1	39	39.9	40.6	43.3	38.9
Payer: Medicare, %	69.9	70	69.5	69.8	69.1	69	68.2	67.9	68.4	67.8	69.8	69.8	69.1
Medicaid, %	3.1	3.2	3.7	3.3	3.3	3.5	3.5	3.4	3.9	4.3	3.8	4.2	3.7
Private, %	23.8	23.4	22.9	22.7	23.6	23	23.6	23.9	22.7	22.8	21.7	20.6	22.8
Self-pay, %	1.8	1.9	2	2.4	2.3	2.3	2.6	2.3	2.9	2.9	2.7	3.1	2.5
No charge, %	0.2	0.2	0.4	0.3	0.3	0.4	0.5	0.4	0.3	0.4	0.3	0.3	0.3
Other, %	1.2	1.3	1.5	1.4	1.4	1.9	1.7	2	1.7	1.9	1.7	2	1.7
CO-MORBIDITIES													
Diabetes, %	17.9	19	19.7	20	20.5	21.8	23.5	23.3	24.7	25.2	25.7	26.5	22.8
Hypertension, %	55	57.6	60	62.5	62.8	65.8	67.6	68.5	70.3	70.8	71.9	73.6	66.6
ACS, %	29.1	29.3	29.8	30.2	30.2	31.5	31.6	31.4	32	31.4	31.4	32.3	31
History of MI, %	27.9	28.3	28.7	29.2	29.4	30.9	31	30.9	31.7	31	30.8	31.8	30.4
Dyslipidemia, %	20.1	22.7	25	28.6	31.9	34.5	38.2	39.7	41.6	43.1	44.8	46.5	36.3
Dementia, %	1	0.8	1.1	1	1	1	0.9	0.9	0.9	0.6	0.7	0.6	0.8
COPD, %	3	3	3.2	3.2	3.6	3.3	3.4	3.9	4.2	4.2	4.5	4.6	3.8
CKD, %	0.7	0.7	0.7	0.6	2.2	6.2	9.8	10.3	12	12.7	14.2	14.9	8.2
CLD, %	0.6	0.7	0.8	0.7	0.8	0.9	0.9	1.1	1.2	1.2	1.3	1.4	1
OUTCOMES													
LOS (days), mean	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.5	3.5	3.5	3.4	3.3	3.5
Died, N	2802	2760	2600	2588	2578	2857	2600	3100	2823	3169	3561	3400	34838
Died, %	1.2	1.2	1.2	1.2	1.1	1.2	1.1	1	0.9	0.9	1	0.9	1
HF, N	50912	50315	51378	54202	57261	64206	63268	81477	93210	100945	111662	117965	896801
HF, %	21.6	22.6	23.1	24.9	25.1	25.9	26	27	28.9	30	30.3	31.1	26.9
Stroke, N	3279	3576	3317	3209	3656	4047	3772	5170	6516	6365	6817	7420	57144
Stroke, %	1.4	1.6	1.5	1.5	1.6	1.6	1.5	1.7	2	1.9	1.8	2	1.7

Abbreviations: ACS = acute coronary syndrome; HF = congestive heart failure; CKD = chronic kidney disease; CLD = chronic liver disease; COPD = chronic obstructive pulmonary disease; LOS = length of stay; MI = myocardial infarction; PI = Pacific Islander.

Table A 4: Atrial fibrillation hospitalization rates by race, per 100,000 US populations. Nationwide Inpatient Sample 2001-12.

Race	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
White	218.2	199.2	191.2	186.1	198.2	206.8	199	247	260	269.3	294.1	298.5
Asian/PI	65.9	70	72.5	63.6	49.6	58.8	66.8	79.3	83.7	67.1	62.5	74.9
Black	105.4	110.5	118.4	120	91.3	118.8	128	133	141	180.1	185	187.3
Hispanic	94.8	98.7	123.6	92.4	87.3	115.5	97.2	106	124	108.9	121.8	117.9

Table A 5: Outcomes by race for patients hospitalized with a primary diagnosis of atrial fibrillation, National Inpatient Sample, 2001-12

Race	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Length of Stay, mean (sem)												
White	3.5 (.01)	3.6 (.02)	3.6 (.02)	3.5 (.02)	3.6 (.02)	3.5 (.01)	3.5 (.01)	3.5 (.01)	3.5 (.01)	3.5 (.01)	3.3 (.01)	3.3 (.01)
Asian/PI	3.8 (.14)	3.7 (.13)	3.6 (.13)	3.5 (.11)	3.5 (.14)	3.7 (.10)	3.5 (.10)	3.3 (.10)	3.4 (.09)	3.5 (.09)	3.2 (.10)	3.2 (.08)
Black	4.6 (.08)	4.4 (.07)	4.3 (.06)	4.5 (.06)	4.5 (.08)	4.5 (.06)	4.3 (.06)	4.2 (.06)	4.2 (.05)	4.0 (.04)	4.0 (.04)	3.9 (.04)
Hispanic	3.9 (.07)	3.9 (.07)	3.8 (.06)	3.8 (.07)	3.6 (.07)	3.8 (.06)	3.7 (.06)	3.7 (.06)	3.7 (.05)	3.8 (.06)	3.5 (.05)	3.5 (.05)
Congestive Heart Failure, OR (95% CI)*												
White	referent	referent	referent	referent	referent	referent	referent	referent	referent	referent	referent	referent
Asian/PI	0.7 [†]	0.8	0.9 [‡]	0.9 [‡]	0.8 [†]	0.8 ^{†‡}	0.9	0.8 ^{†‡}	0.7 ^{†‡}	0.9	0.9	1
	(0.6, 0.9)	(0.7, 1.0)	(0.7, 1.1)	(0.7, 1.1)	(0.6, 1.0)	(0.6, 0.9)	(0.8, 1.1)	(0.7, 0.9)	(0.6, 0.9)	(0.8, 1.1)	(0.7, 1.0)	(0.8, 1.1)
Black	1.7 ^{†‡}	1.6 ^{†‡}	1.7 ^{†‡}	1.6 ^{†‡}	1.6 ^{†‡}	1.5 ^{†‡}	1.7 ^{†‡}	1.6 ^{†‡}	1.6 ^{†‡}	1.7 ^{†‡}	1.6 ^{†‡}	1.5 ^{†‡}
	(1.6, 1.9)	(1.5, 1.8)	(1.5, 1.8)	(1.5, 1.8)	(1.5, 1.8)	(1.4, 1.7)	(1.6, 1.8)	(1.5, 1.7)	(1.5, 1.8)	(1.6, 1.8)	(1.5, 1.7)	(1.5, 1.6)
Hispanic	1.2 ^{†‡}	1.2 ^{†‡}	1.0 [‡]	1.1 ^{†‡}	1.2 ^{†‡}	1.1 [‡]	1.1 [‡]	1.1 [†]	1.0 [‡]	1.2 ^{†‡}	1.1 ^{†‡}	1.1 [†]
	(1.1, 1.4)	(1.1, 1.3)	(0.9, 1.1)	(1.0, 1.2)	(1.0, 1.3)	(1.0, 1.2)	(1.0, 1.2)	(1.0, 1.2)	(0.9, 1.1)	(1.1, 1.3)	(1.0, 1.2)	(1.0, 1.1)
Stroke, OR (95% CI)*												
White	referent	referent	referent	referent	referent	referent	referent	referent	referent	referent	referent	referent
Asian/PI	0.8	0.8 [‡]	0.9	0.7	0.8	0.6	0.7	0.6	0.6	1.0 [‡]	0.7	0.6
	(0.4, 1.8)	(0.4, 1.6)	(0.5, 1.8)	(0.3, 1.6)	(0.4, 1.8)	(0.3, 1.3)	(0.4, 1.4)	(0.3, 1.1)	(0.3, 1.1)	(0.6, 1.6)	(0.4, 1.3)	(0.4, 1.1)
Black	0.8	1.1	0.9	0.9	0.7	0.9	0.9	0.7 [†]	0.6 [†]	0.9	0.8	0.7 [†]
	(0.5, 1.2)	(0.8, 1.5)	(0.6, 1.2)	(0.6, 1.2)	(0.5, 1.0)	(0.7, 1.3)	(0.7, 1.2)	(0.5, 0.9)	(0.4, 0.8)	(0.7, 1.2)	(0.6, 1.0)	(0.5, 0.9)
Hispanic	1	1	0.8	1	0.8	0.7 [†]	0.6 [†]	1	0.8	0.8	0.8 [‡]	0.9
	(0.7, 1.5)	(0.7, 1.5)	(0.5, 1.1)	(0.7, 1.5)	(0.5, 1.2)	(0.5, 1.0)	(0.4, 1.0)	(0.8, 1.4)	(0.6, 1.0)	(0.6, 1.1)	(0.6, 1.1)	(0.7, 1.1)
Death, OR (95% CI)*												
White	referent	referent	referent	referent	referent	referent	referent	referent	referent	referent	referent	referent
Asian/PI	1.1	0.5 [‡]	1.1	1	1.4	0.9	2.0 [†]	1.4	1	1.3	1.2	0.5
	(0.5, 2.5)	(0.2, 1.4)	(0.5, 2.5)	(0.5, 2.2)	(0.6, 3.2)	(0.4, 2.1)	(1.1, 3.5)	(0.8, 2.5)	(0.5, 2.1)	(0.7, 2.5)	(0.6, 2.4)	(0.2, 1.2)
Black	1.8 [†]	2.1 [†]	1.5 [†]	2.1 [†]	1.4	1.8 [†]	1.5 [†]	2.1 [†]	1.5 [†]	1.6 [†]	1.3 [†]	1.2
	(1.3, 2.4)	(1.5, 2.8)	(1.1, 2.0)	(1.6, 2.8)	(1.0, 2.1)	(1.4, 2.4)	(1.1, 2.1)	(1.6, 2.8)	(1.1, 2.1)	(1.2, 2.1)	(1.0, 1.8)	(0.9, 1.7)
Hispanic	0.7	1.1	1.2	1.4	1	0.8	1.5 [†]	1.6 [†]	0.9	1.2	0.9	1.1
	(0.4, 1.2)	(0.7, 1.7)	(0.9, 1.8)	(0.9, 2.0)	(0.7, 1.6)	(0.6, 1.3)	(1.0, 2.3)	(1.1, 2.2)	(0.6, 1.4)	(0.8, 1.8)	(0.6, 1.3)	(0.8, 1.6)

PI = Pacific Islander; se = Standard error of the mean.

* Multivariable regression adjusting for age, sex, hospital location (urban vs. rural), university hospital (teaching vs. non-teaching), payor, geographic region and co-morbidities including hypertension, diabetes, Dyslipidemia, history of myocardial infarction, dementia, chronic obstructive pulmonary disease, chronic kidney disease and chronic liver disease. For the outcome of death, HF and stroke were also included in the regression adjustment.

[†] p < .05.

[‡] Interaction present between race and age for the association shown.

Figure A 1: Outcomes, by race and year. (A) mean length of stay (days). Odds ratios for (B) HF, and (C) stroke, adjusted for age, sex, comorbidities (diabetes, hypertension, history of myocardial infarction, dyslipidemia, COPD, CKD, CLD), hospital location, hospital teaching status, payer, region. White = referent. Linear trend lines by race are shown.

Figure A:

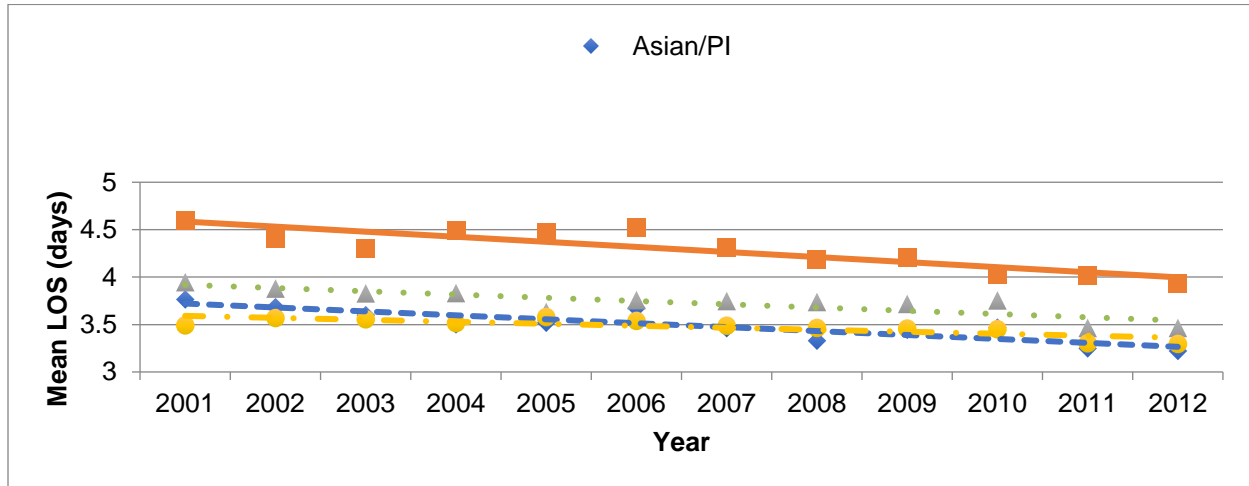


Figure B: HF

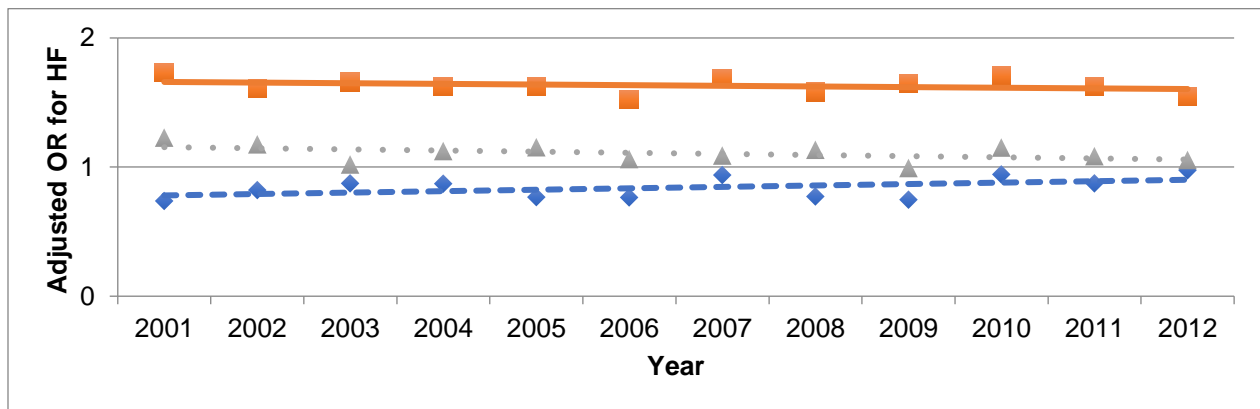


Figure C: Stroke

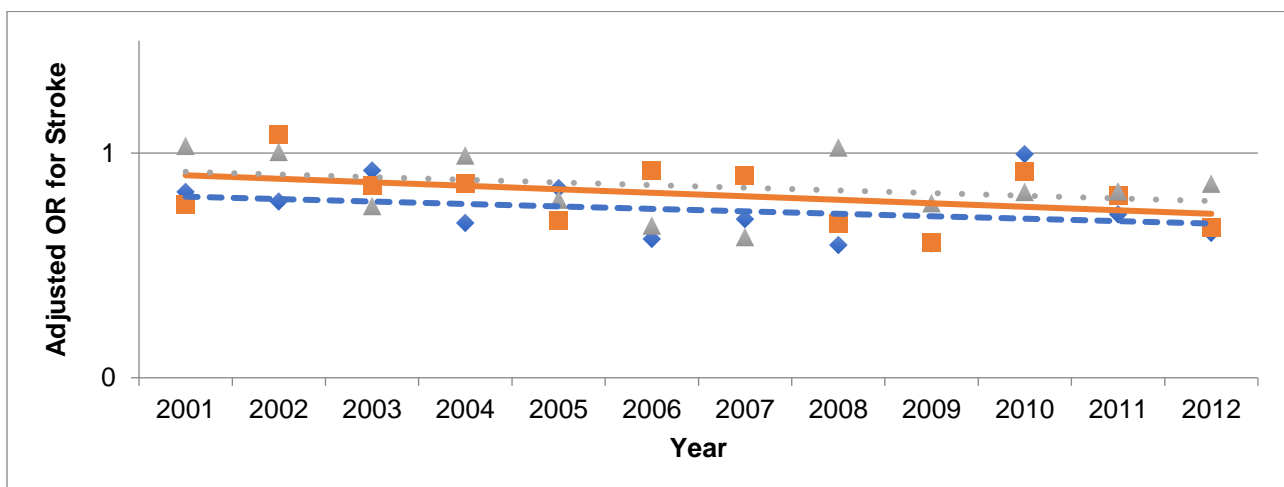


Table A 6: Associations between black race, and in-hospital death and procedures adjusting for center confounding for patients hospitalized primarily for AF in NIS 2001 and 2012. Models comparing predicted outcomes of a theoretical hospital with 0% vs. 100% proportion of patients signifying black race

	Procedures		Death	
	2001	2012	2001	2012
Adjusted for covariates (presence or absence of Black race vs. White)				
Combined across- and within-center	0.55 (0.48, 0.62)	0.54 (0.50, 0.59)	1.78 (1.31, 2.43)	1.23 (0.92, 1.64)
Adjusted for covariates and confounding by center (100% increase in the proportion of patients hospitalized who are black)				
Within-center (similar racial mix)	0.57 (0.49, 0.68)	0.54 (0.48, 0.60)	1.71 (1.21, 2.41)	1.05 (0.74, 1.49)
Across-center (differing racial mix)	0.46 (0.24, 0.88)	0.55 (0.35, 0.87)	2.06 (0.98, 4.32)	2.06 (1.16, 3.70)

Supplementary References

Agency for Healthcare Research and Quality. Rockville MD. HCUP Databases. Healthcare Cost and Utilization Project (HCUP).