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ORIGINAL RESEARCH

Race Differences in Interventions and Survival After Out-of-Hospital Cardiac Arrest in North Carolina, 2010 to 2014

Sidsel Moeller, MD, PhD; Carolina M. Hansen, MD, PhD; Kristian Kragholm, MD, PhD; Matt E. Dupre, PhD; Comilla Sasson, MD, PhD; David A. Pearson, MD; Clark Tyson, MS, NREMT-P; James G. Jollis, MD; Lisa Monk, MSN, RN; Monique A. Starks, MD; Bryan McNally, MD; Kevin L. Thomas, MD; Lance Becker, MD; Christian Torp-Pedersen, MD, DMSc; Christopher B. Granger, MD

BACKGROUND: Following the implementation of the HeartRescue project, with interventions in the community, emergency medical services, and hospitals to improve care and outcomes for out-of-hospital cardiac arrests (OHCA) in North Carolina, improved bystander and first responder treatments as well as survival were observed. This study aimed to determine whether these improvements were consistent across Black versus White individuals.

METHODS AND RESULTS: Using the Cardiac Arrest Registry to Enhance Survival (CARES), we identified OHCA from 16 counties in North Carolina (population 3 million) from 2010 to 2014. Temporal changes in interventions and outcomes were assessed using multilevel multivariable logistic regression, adjusted for patient and socioeconomic neighborhood-level factors. Of 7091 patients with OHCA, 36.5% were Black and 63.5% were White. Black patients were younger, more females, had more unwitnessed arrests and non-shockable rhythm (Black: 81.0%; White: 75.4%). From 2010 to 2014, the adjusted probabilities of bystander cardiopulmonary resuscitation (CPR) went from 38.5% to 51.2% in White, $P<0.001$; and 36.9% to 45.6% in Black, $P=0.002$, and first-responder defibrillation went from 13.2% to 17.2% in White, $P=0.002$; and 14.7% to 17.3% in Black, $P=0.16$. From 2010 to 2014, survival to discharge only increased in White (8.0% to 11.4%, $P=0.004$; Black 8.9% to 9.5%, $P=0.60$), though, in shockable patients the probability of survival to discharge went from 24.8% to 34.6% in White, $P=0.02$; and 21.7% to 29.0% in Black, $P=0. 10$.

CONCLUSIONS: After the HeartRescue program, bystander CPR and first-responder defibrillation increased in both patient groups; however, survival only increased significantly for White patients.

Key Words: intervention ■ OHCA ■ race ■ survival

Out-of-hospital cardiac arrest (OHCA) remains a significant health problem with a poor prognosis, affecting ≈700 000 people in North America and Europe annually[1,2] of which around 10% survive.[2] Over the years, several initiatives in cardiac arrest management have been implemented worldwide with subsequent improved survival.[3-5] However, overall outcomes remain poor and vary across different patient and cardiac arrest-related characteristics as highlighted in the recent Institute of Medicine (IOM) report, "Strategies to Improve Cardiac Arrest Survival: A Time to Act." The IOM report specifically called for studies to improve understanding of differences across race and socioeconomic aspects that will help identify future targets for improving care and outcomes for underprivileged groups.[6] In this context, racial differences are of great importance since previous studies have shown that Black patients are much more likely to suffer a cardiac

Correspondence to: Sidsel Møller MD, PhD, Duke Clinical Research Institute, 200 Morris Street, 27715 Durham, North Carolina. E-mail: sidsel.gamborg.moeller@regionh.dk

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CLINICAL PERSPECTIVE

What Is New?

- Following the implementation of the HeartRescue project with interventions in the community, emergency medical services, and hospitals to improve care and outcomes for out-of-hospital cardiac arrests in North Carolina from 2010 to 2014, bystander cardiopulmonary resuscitation and first-responder defibrillation increased in both Black and White patients, though overall survival only increased significantly in White patients.
- Looking at patients with an initial shockable rhythm, improved survival was observed for both Black and White patients, indicating that the observed lower frequency of initial shockable rhythm among Black patients could be an important contributor.

What Are the Clinical Implications?

- The interventions appear to be effective at improving bystander cardiopulmonary resuscitation and early defibrillation irrespective of race, although survival was significantly improved only in White patients. Further research in improving care and outcomes in Black patients is needed.

Nonstandard Abbreviations and Acronyms

CARES	Cardiac Arrest Registry to Enhance Survival
CPC	Cerebral Performance Category
IOM	Institute of Medicine
OHCA	out-of-hospital cardiac arrest
PP	predicted probabilities
RACE-CARS	Regional Approach to Cardiovascular Emergencies Cardiac Arrest Resuscitation System
VIF	variance inflation factors

arrest at a younger age, less likely to receive bystander cardiopulmonary resuscitation (CPR) and defibrillation, and ultimately less likely to survive.[7-10] Socioeconomic status has earlier been suggested as an explaining factor for racial difference,[11,12] but studies on this field are lacking and other factors including biological differences may also be important.

In 2010, North Carolina initiated the North Carolina Regional Approach to Cardiovascular Emergencies Cardiac Arrest Resuscitation System (RACE-CARS) program as part of the HeartRescue project,[13] and by this implemented multifaceted interventions with population-based training in CPR and use of automated external defibrillators (AED) as well as dispatch center training in recognizing cardiac arrests. Subsequently, an increase in both bystander and first-responder interventions (CPR and defibrillation) and survival from OHCA in North Carolina was observed from 2010.[14] However, it remains unknown whether the effects of these interventions in North Carolina from 2010 to 2014 differed between Black and White race. The aim of this study was therefore to assess Black and White differences in bystander CPR, defibrillation, and survival following the implementation of the RACE-CARS program/HeartRescue project.

METHODS

The authors declare that all supporting data are available within the article and its online supplementary files.

Data Source and Setting

This study is based on the CARES (Cardiac Arrest Registry to Enhance Survival) registry, which is a voluntary, prospective clinical registry including all nontraumatic patients with OHCA where resuscitation has been attempted by a 911 responder in the United States. The registry was established by the Centers for Disease Control and Prevention and Emory University for public health surveillance and continuous quality improvement.[15,16] Data are collected from emergency medical service (EMS) agencies and receiving hospitals and afterwards reviewed for completeness and accuracy by a CARES analyst according to the Utstein template.[15] As part of the HeartRescue Project in North Carolina participating EMS agencies received training, quality control, and data feedback.

The included EMS agencies in this study all had a two-tiered response system with first responders armed with AEDs[17] and the EMS (paramedics). First responders are defined by CARES as "personnel who respond to the medical emergency in an official capacity as part of an organized medical response team, but are not the designated transporter of the patient to the hospital,"[17] and in North Carolina consists of firefighters, police officers and other life-saving and rescue squads trained to perform basic life support until EMS arrives. Bystanders are defined as other people on the scene and not dispatched by the dispatch centers.[18]

The location of the OHCAs was based on the physical address of the OHCA and was geocoded by ArcGIS 10.2 software (ESRI, Redlands, CA). The geocoding assigned a latitude and longitude coordinate to each address. We achieved a 97% geocoding rate, where non-geocoded records included PO boxes and other non-physical locations. This process verified

the county in which each OHCA occurred. We used census tracts as proxies for neighborhoods, as previously done,[19] since they represent socio-economically homogeneous groups of 4000 to 7000 people.[20] The 2010 United States Census Summary Files were used to link each geocoded address with neighborhood-level variables as median household income, percentage with high school diploma, urban (areas of >2500 people) and rural census information etc.[21]

The HeartRescue Project in North Carolina

In 2010, North Carolina initiated a statewide multifaceted quality-improvement program (RACE-CARS) as a part of the HeartRescue Project.[13] The project protocol is freely available, and the project has previously been described in detail elsewhere.[14,22] Overall, the project included interventions for hospital personnel and administration (with establishment of in-hospital treatment protocols), EMS dispatchers (with training in recognizing of cardiac arrest, provide assisted-CPR, and implement protocols for transporting of the patients), first responders (with instruction in team-based high-quality CPR and AED use), and community members (with CPR and AED training).

Study Population

We identified all adult patients of Black and White race with OHCA of presumed cardiac etiology from 16 counties in North Carolina (population ≈3 million) from the CARES registry with complete registry enrollment during the entire study period (2010–2014) as done previously.[14] Following Utstein guidelines, we excluded EMS-witnessed cases and cases with "do not resuscitate" orders[18] as well as cases with non-matched geo-coding, missing or other race than Black or White. Figure 1 shows the study selection process. Patient race was obtained from the CARES registry where it is reported by the patient, family or healthcare provider, as defined by CARES registry guidelines.[17]

Outcomes

The outcomes were bystander and first responder initiation of CPR and defibrillation, survival to discharge and survival with favorable neurologic outcome (Cerebral Performance Category [CPC] 1–2), for Black compared with White patients.

Statistical Analysis

Descriptive statistics of overall characteristics and outcomes according to patient race were shown as frequencies and percentages for categorical variables and as medians with 25%–75% percentiles for continuous variables. To simplify interpretation and to provide identifiable cutoffs/thresholds that are more useful for identifying areas for intervention we divided the neighborhood variables: household income and education in subgroups that for income was based on tertiles. Differences between the Black and White patients were tested with Chi-Square tests for categorical variables and the Kruskall-Wallis tests for continuous variables. *P* values <0.05 were considered statistically significant. Only complete case analyses were performed.

Multilevel logistic regression analyses with mixed models were used to examine differences in bystander and first responder interventions as well as survival to discharge and survival with favorable neurological outcome for Black patients versus White patients from 2010 to 2014. We used multilevel logistic regression models to account for patients nested within census tracts. Interactions between patient race and time (year) were included to account for potential temporal differences between the patient groups. The regression models for the association between patient race, bystander and first responder CPR and defibrillation were performed in 3 steps (1) unadjusted, (2) adjusted for patient factors (age and sex) and neighborhood factors (neighborhood income, educational status, urban/rural setting), and (3) adjusted for patient factors, neighborhood factors, and location of arrest, witnessed status, and rhythm. The results from the unadjusted models (1) and the patient and neighborhood adjusted models (2) are presented in the supplemental material. The regression models for the association between patient race and survival status were performed in 4 steps: (1) unadjusted, (2) adjusted for patient factors (age, sex, location of arrest, witnessed status, and rhythm), (3) adjusted for patient and neighborhood factors (neighborhood income, neighborhood educational status, urban/rural setting), and (4) adjusted for patient factors, neighborhood factors and interventions (bystander and first responder CPR and defibrillation). The changes in interventions and outcomes were also examined in a more homogenous population of patients with initial shockable heart rhythm (n=1595 patients). Predicted probabilities (PP and 95% CI) were calculated from the multilevel logistic regression models and reported as percentages (PP×100) to facilitate interpretation of the key findings; and *P* values were reported for the trend within each patient group (Black and White patients) and for the tests of interactions between patient race and time (temporal change).

Tests of multicollinearity among covariates (namely neighborhood variables) were assessed based on variance inflation factors (VIF), tolerance levels, and condition values; and the results suggested no evidence of collinearity in the models (eg, VIFs≤2.87).

All analyses where performed using SAS version 9.4 (SAS institute, Cary, NC) and Stata version 15.0 (StataCorp, College Station, TX).

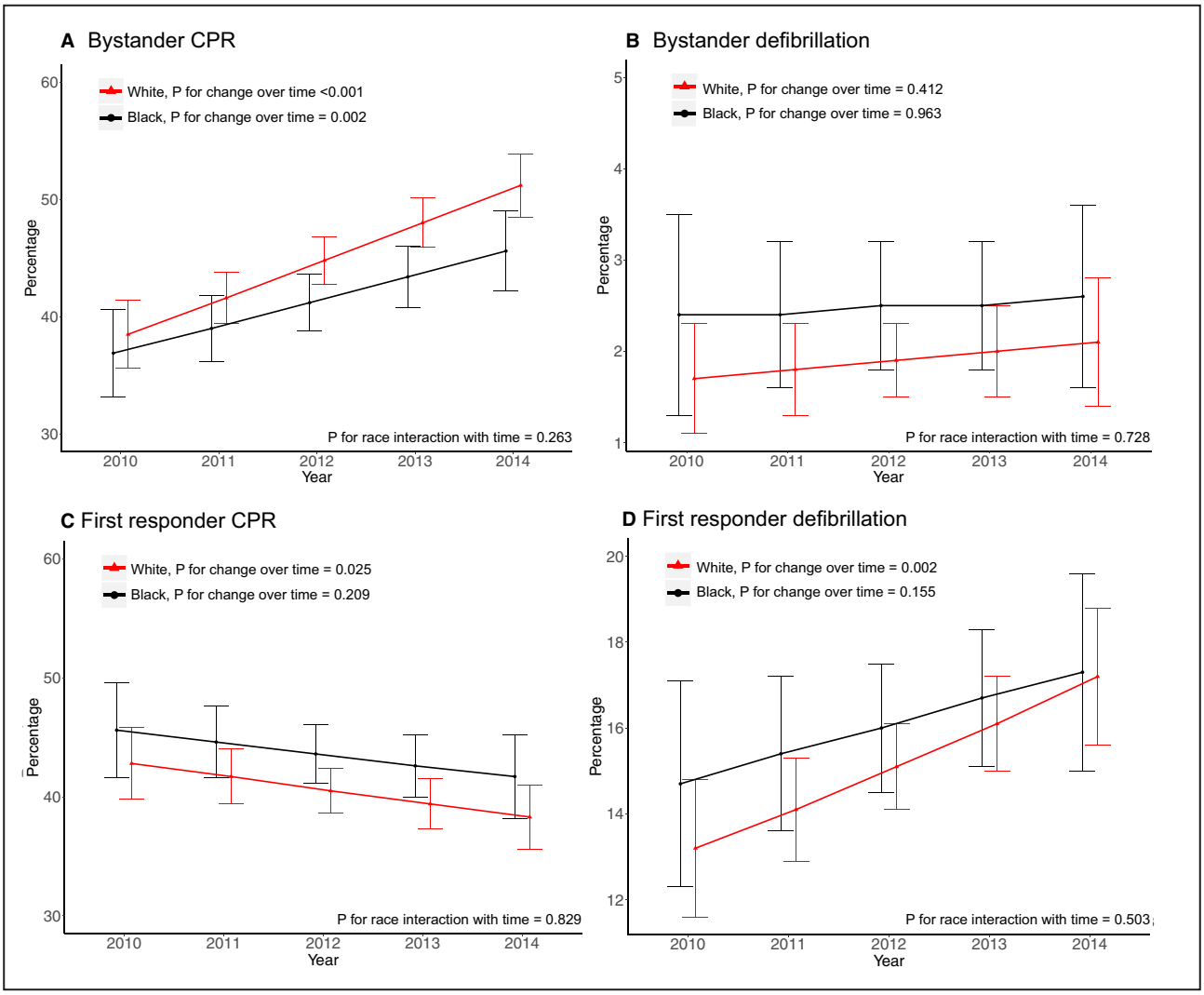

Figure 1. Predicted probabilities of bystander and first responder CPR and defibrillation.
Adjusted predicted probabilities with 95% CIs from 2010 to 2014 for bystander CPR (**A**), bystander defibrillation (**B**), first responder CPR (**C**) and first responder defibrillation (**D**) in Black and White patients. The analyses are adjusted for age, sex, location of arrest, witnessed status, initial heart rhythm and neighborhood factors (income, education and urban/rural status) and includes an interaction between race and calendar year. The interaction is showed as a *P* value in the Figure. A *P* value <0.05 is considered statistically significant. CPR indicates cardiopulmonary resuscitation; and OHCA, out-of-hospital cardiac arrest.

Ethics

This study was approved by the Duke University Medical Center Institutional Review Board for analyses and publication of the findings. A waiver of the requirement for written informed consent and Health Insurance Portability and Accountability Act authorization was granted on the basis of (1) using existing central CARES registry data and under existing waiver of HIPAA consent, and (2) using aggregated and limited data.

RESULTS

The patient selection process is shown in Figure S1. Of 7091 patients, 36.5% were Black and 63.5% were White. The overall incidence of OHCA per 100 000 inhabitants per year was 54.7, with corresponding 71.3 patients with OHCA of Black race and 48.3 of White race per 100 000 inhabitants per year. Baseline characteristics are shown in Table. Black patients were younger, more often female, unwitnessed, and had a non-shockable heart rhythm (Black: 81.0%; White: 75.4%), also in witnessed arrests with bystander CPR (Black: 64.9%; White: 59.8%). The median EMS response time was 8 minutes in both Black and White patients.

Neighborhood Characteristics

Black patients with OHCA were more likely to arrest in neighborhoods that were urban (Black: 91.7%; White: 73.0%), had a lower percentage of residents with high school diplomas (Black: 43.5%; White: 27.3%), and

Table. Overall Characteristics

	Black (n=2591)	White (n=4500)	*P* Value	In total (n=7091)	Missing data
Average background population per year (2010–2014)*	727 000	1 866 000	…	2 593 000	…
Incidence per 100 000 inhabitants per year	71.3	48.2	…	54.7	…
Patient-related factors:					
Median age (Q1–Q3)	63 (53–75)	68 (56–79)	<0.001	66 (55–78)	12 (0.2)
Female sex, n (%)	1171 (45.2)	1547 (34.4)	<0.001	2718 (38.3)	1
Cardiac arrest-related factors:					
Arrests in private homes, n (%)	2046 (79.0)	3578 (79.5)	0.59	5624 (79.3)	…
Witnessed arrests, n (%)	1080 (41.7)	2108 (46.9)	<0.001	3188 (45.0)	1
Who initiated CPR, n (%)					
Bystander	1083 (42.7)	2113 (48.5)	<0.001	3196 (46.4)	196 (2.8)
First responder	1084 (42.7)	1695 (38.9)	<0.001	2779 (40.3)	196 (2.8)
EMS	369 (14.6)	551 (12.6)	<0.001	920 (13.3)	196 (2.8)
AED application prior to EMS arrival, n (%)					
AED application by bystander	121 (5.5)	161 (3.9)	0.009	282 (4.5)	784 (11.1)
AED application by first responder	985 (44.5)	1784 (43.6)	0.009	2769 (43.9)	784 (11.1)
AED use, n (%)					
AED use by bystander	62 (2.4)	98 (2.2)	0.55	160 (2.3)	3
AED use by first responder	352 (13.6)	747 (16.6)	<0.001	1099 (15.5)	3
AED use in shockable patients, n (%)					
AED use by bystander	40 (8.2)	72 (6.5)	0.24	112 (7.0)	…
AED use by first responder	236 (48.2)	524 (47.4)	0.78	760 (47.6)	…
Median EMS response time (Q1–Q3)†	8 (6–9)	8 (6–11)	<0.001	8 (6–10)	391 (5.5)
Initial shockable heart rhythm, n (%)	490 (18.9)	1105 (24.6)	<0.001	1595 (22.5)	3 (0.1)
Shockable rhythm in witnessed arrests with bystander CPR, n (%)	170 (35.1)	454 (40.2)	0.05	624 (38.6)	2 (0.1)
Area-related factors:					
Household income, USD					
Low income (<40 000)	1247 (48.1)	1254 (27.9)	<0.001	2501 (35.3)	…
Medium income (40–54 999)	731 (28.2)	1505 (33.4)	<0.001	2236 (31.5)	…
High income (≥55 000)	613 (23.7)	1741 (38.7)	<0.001	2354 (33.2)	…
Percentage of high school diploma or higher, n (%)					
Areas of <80% with high school diploma or higher	1128 (43.5)	1228 (27.3)	<0.001	2356 (33.2)	…

(*Continued*)

Table. Continued

	Black (n=2591)	White (n=4500)	*P* Value	In total (n=7091)	Missing data
Areas of 80–90% with high school diploma or higher	842 (32.5)	1522 (33.8)	<0.001	2364 (33.3)	…
Areas of >90% with high school diploma or higher	621 (24.0)	1750 (38.9)	<0.001	2371 (33.5)	…
Urban area, n (%)	2375 (91.7)	3283 (73.0)	<0.001	5658 (79.8)	…
In-hospital care:‡					
Therapeutic hypothermia in hospital, (%)	378 (63.6)	656 (60.9)	0.26	1034 (61.8)	115 (6.4)
Performed coronary angiography, (%)	118 (27.1)	310 (35.7)	0.01	428 (32.8)	483 (27.0)
Cardiac stent placed in patients with performed coronary angiography, n (%)	39 (33.6)	145 (47.1)	0.01	184 (43.4)	4 (0.9)
Outcomes:					
ROSC, n (%)	691 (26.8)	1317 (29.3)	0.02	2008 (28.4)	18 (0.3)
In shockable arrests, n (%)	251 (51.3)	543 (49.1)	0.42	794 (49.8)	1 (0.1)
Survival to discharge, n (%)	235 (9.1)	432 (9.7)	0.45	667 (9.5)	32 (0.5)
In shockable arrests, n (%)	147 (30.1)	314 (28.6)	0.54	461 (29.1)	10 (0.6)
Survival with favorable neurological outcome (CPC 1–2)	193 (7.5)	387 (8.7)	0.09	580 (8.2)	32 (0.5)

Q1–Q3=interquartile range. AED indicates automated external defibrillator; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; and ROSC, return of spontaneous circulation.

*Average background population from 2010 to 2014, rounded to nearest 1000.

†The EMS response time was calculated based on time of receipt of 911-call at the dispatch center of arrest to time of EMS/ambulance arrival on scene.

‡Numbers for the in-hospital factors are based on patients admitted to the hospital (n=1787 patients). Missing data on 17 patients.

with lower median household income (Black: 48.1%; White: 27.9%) compared with White patients with OHCA (Table).

Cardiopulmonary Resuscitation

Black patients had lower bystander CPR (Black: 42.7%; White: 48.5%), but higher first responder CPR (Black: 42.7%; White: 38.9%) (Table), compared with White patients. From 2010 to 2014, the fully adjusted probability of bystander CPR increased significantly in both patient groups (Black: 36.9% [95% CI 33.2%–40.6%] in 2010 to 45.6% [95% CI 42.2%–49.0%] in 2014, *P*=0.002; White: 38.5% [95% CI 35.6%–41.4%] in 2010 to 51.2% [95% CI 48.5%–53.9%] in 2014, *P*<0.001) (Figure 1A), whereas first responder CPR went from 45.7% [95% CI 41.8%–49.6%] in 2010 to 41.9% [95% CI 38.5%–45.3%] in 2014 in Black patients, (*P*=0.21) and from 43.0% [95% CI 40.4%–45.6%] in 2010 to 38.5% [95% CI 35.9%–41.1%] in 2014 in White patients (*P*=0.03) (Figure 1C). Though, no significant difference between the 2 groups was observed (*P*=0.83). Overall the same trends were observed in the crude analysis and when adjusting only for age, sex, and neighborhood factors (Figure S2 and S3), as well as in only shockable patients (Figure 2).

Defibrillation

No difference was found overall in AED application and bystander defibrillation between the 2 groups (Black: 2.4%; White: 2.2%), whereas Black patients were less likely to be defibrillated by a first responder compared to White patients (Black: 13.5%; White: 16.6%) (Table). Over the study period, no significant temporal change was observed in bystander defibrillation, but first responder defibrillation went from 14.7% [95% CI 12.3%–17.1%] in 2010 to 17.3% [95% CI 15.0%–19.6%] in 2014 in Black patients, (*P*=0.16) and from 13.2% [95% CI 11.6%–14.8%] in 2010 to 17.2% [95% CI 15.6%–18.8%] in 2014 in White patients (*P*<0.001). The trend was only statistically significant for White patients, though no substantial differences in temporal trends between the 2 groups in either bystander (*P*=0.73) or first responder defibrillation (*P*=0.50) were observed (Figure 1B and 1D). The same trend was observed in the crude analysis and when adjusting for only age, sex, and neighborhood factors (Figure S2 and S3). A small temporal non-significant increase was observed in bystander defibrillation for both

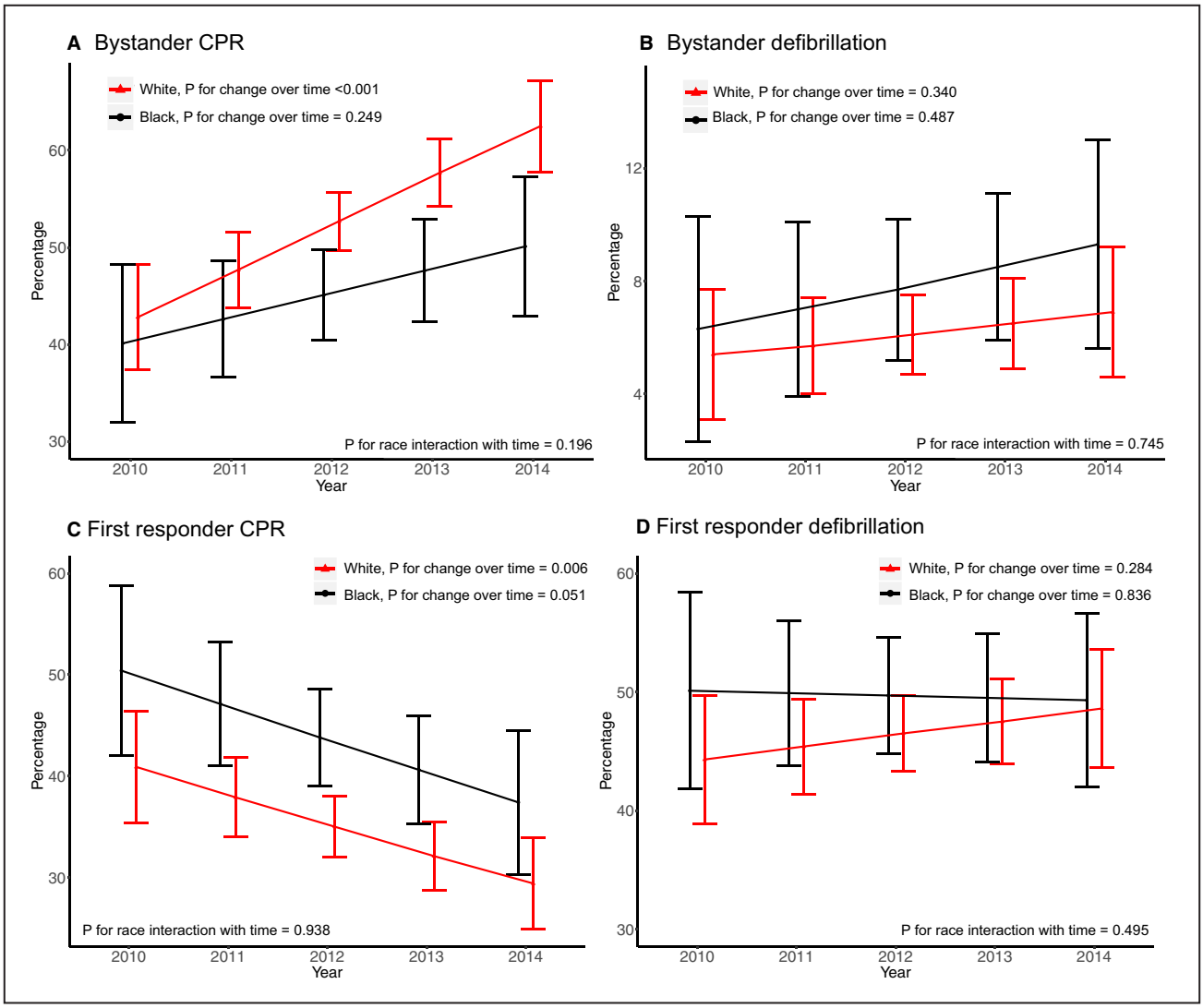

Figure 2. Predicted probabilities of bystander and first responder CPR and defibrillation in patients with shockable heart rhythm.

Adjusted predicted probabilities with 95% CIs from 2010 to 2014 for bystander CPR (**A**), bystander defibrillation (**B**), first responder CPR (**C**) and first responder defibrillation (**D**) in Black and White patients in only shockable patients. The analyses are adjusted for age, sex, location of arrest, witnessed status and neighborhood factors (income, education, and urban/rural status) and includes an interaction between race and calendar year. The interaction is showed as a *P* value in the Figure. A *P* value <0.05 is considered statistically significant. CPR indicates cardiopulmonary resuscitation; and OHCA, out-of-hospital cardiac arrest.

groups, but only for White patients in first responder defibrillation in shockable patients (Figure 2B and 2D).

Survival

The estimated crude and adjusted probability of return of spontaneous circulation increased significantly for both patient groups from 2010 to 2014 (Figure S4). Figure 3 shows the estimated probabilities of survival to discharge from 2010 to 2014. Both in crude and adjusted models, the probabilities of survival increased significantly for White patients, whereas survival remained overall similar for Black over time (fully adjusted analysis: Black: 8.9% [95% CI 7.0%–10.8%] in 2010 to 9.5% [95% CI 7.8%–11.2%] in 2014, *P*=0.60 versus White: 8.0% [95% CI 6.6%–9.4%] in 2010 to 11.4% [95% CI 9.9%–12.9%] in 2014, *P*=0.004; *P* for difference between the 2 groups=0.14). The same was observed for survival with favorable neurological outcome (Figure S5). In a restricted analysis including only patients with an initial shockable rhythm, the estimated adjusted probability for survival to discharge went from 21.7% [95% CI 15.3%–28.1%] in 2010 to 29.0% [95% CI 22.9%–35.1%] in 2014 in Black patients (*P*=0.10) and from 24.8% [95% CI 20.1%–29.5%] in 2010 to 34.6% [95% CI 29.9%–39.3%] in 2014 in White patients

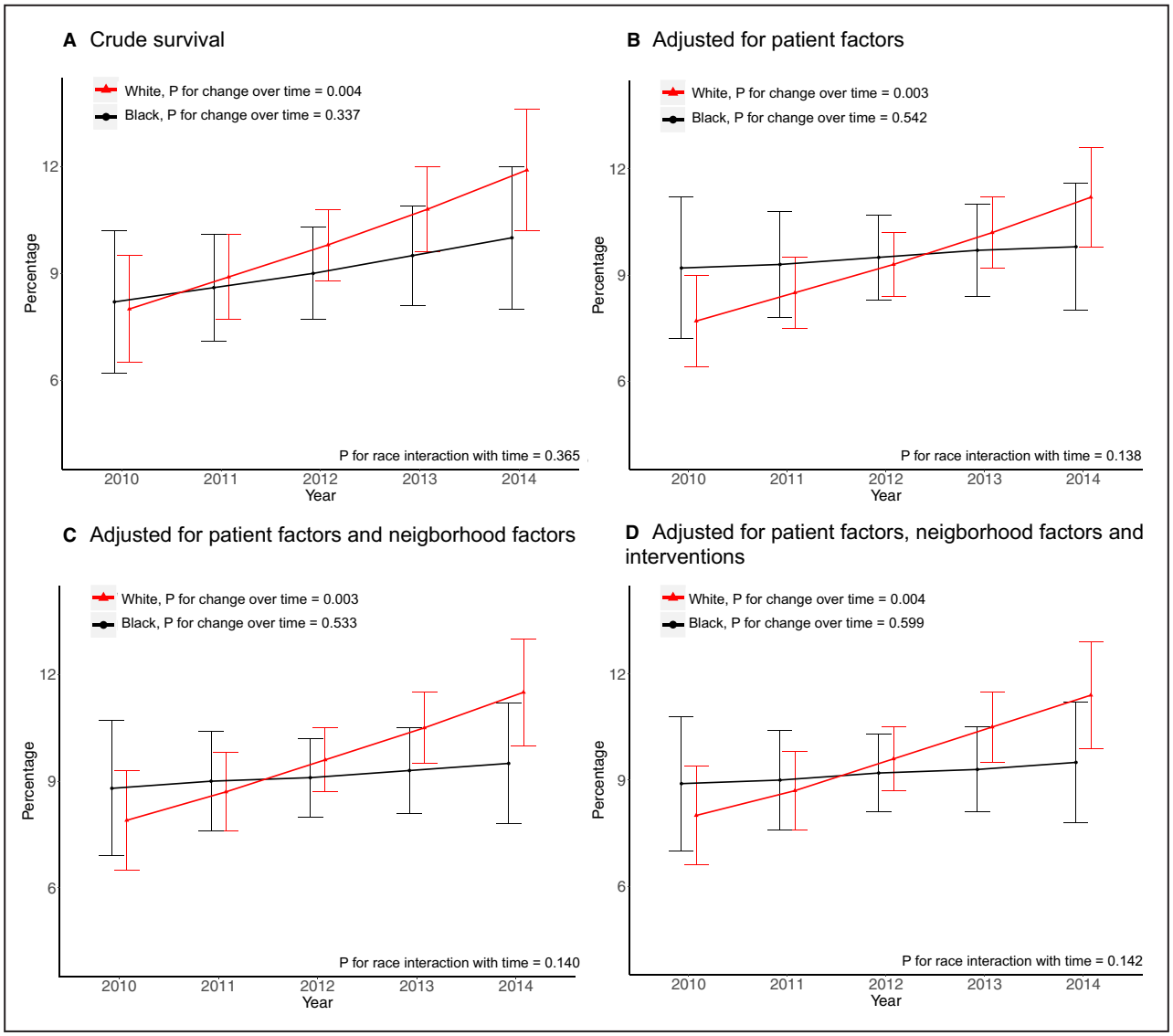

Figure 3. Predicted probabilities of survival to discharge.
Predicted probabilities for survival to discharge with 95% CIs from 2010 to 2014 comparing Black and White patients. The Figure shows (**A**) a crude analysis, (**B**) adjusted for patient factors (age, sex, location of arrest, witnessed status, and initial rhythm), (**C**) adjusted for patient factors and neighborhood factors (income, education, urban/rural status) and (**D**) adjusted for patient factors, neighborhood factors and interventions (bystander and first responder CPR and defibrillation). All analyses include an interaction between race and calendar year. The interaction is showed as a *P* value in the Figure. A *P* value <0.05 is considered statistically significant. CPR indicates cardiopulmonary resuscitation; and OHCA, out-of-hospital cardiac arrest.

(*P*=0.02) (Figure 4). There was no significant difference between the groups (*P*=0.78).

DISCUSSION

This study aimed to examine potential racial differences and changes in rates of bystander and/or first responder interventions due to the implementation of the RACE-CARS program/HeartRescue project in North Carolina from 2010 to 2014, and to analyze changes in survival, accounting especially for neighborhood characteristics. Our study had 3 main findings: (1) from 2010 to 2014 bystander CPR and first responder defibrillation increased significantly in White patients, whereas only bystander CPR increased significantly in Black patients where an overall lower rate also was observed compared to White patients; (2) even though no significant difference was observed between the 2 groups, survival to discharge and survival with favorable neurological outcome increased significantly for White patients from 2010 to 2014, whereas no change was observed for Black patients in the time period. This was observed both in crude and adjusted analyses of non-modifiable factors (age, sex, location of arrest, witnessed status,

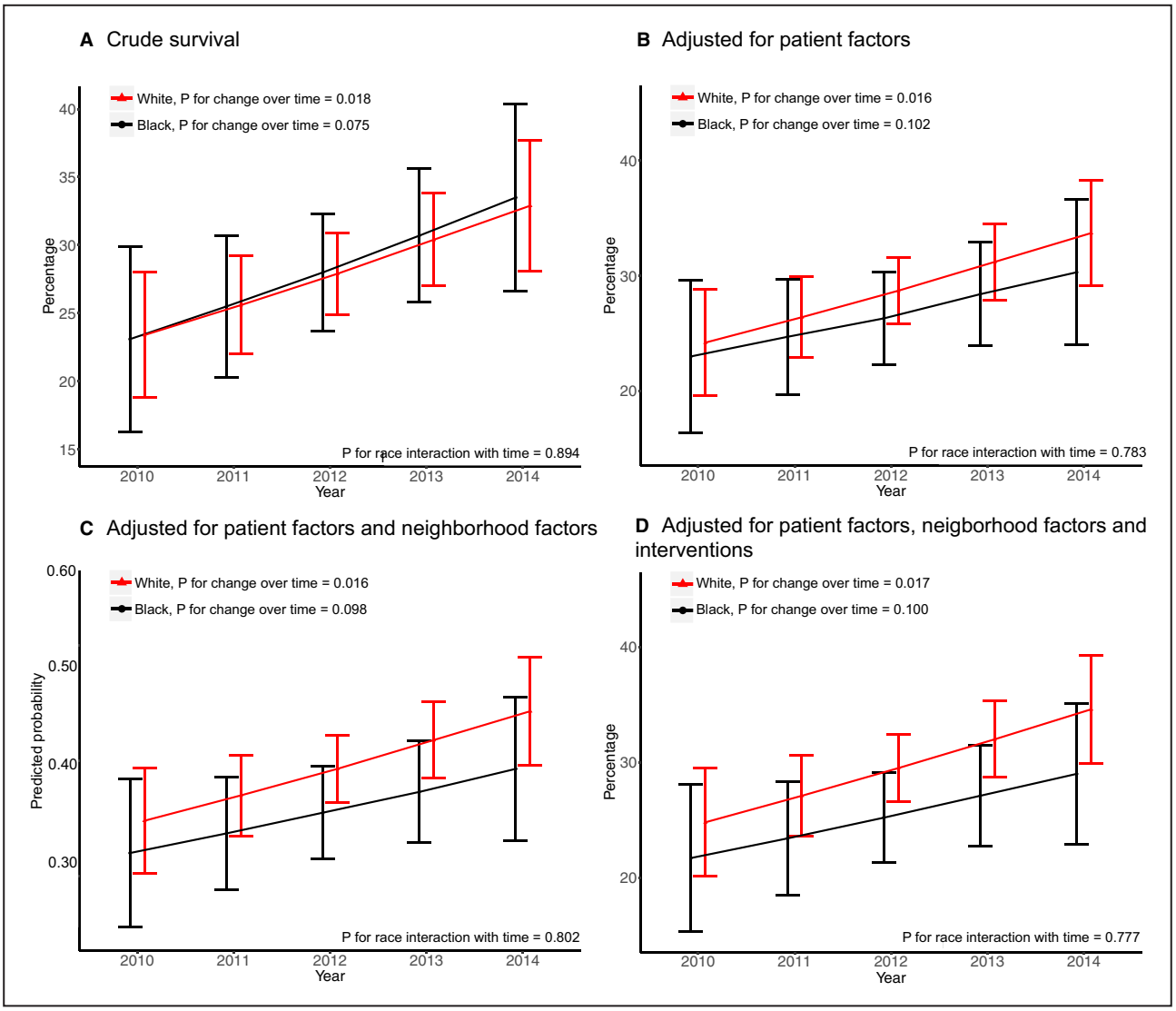

Figure 4. Predicted probabilities of survival to discharge in patients with shockable heart rhythm.
Predicted probabilities for survival to discharge in only shockable patients with 95% CIs from 2010 to 2014 comparing Black and White patients. The Figure shows (**A**) a crude analysis, (**B**) adjusted for patient factors (age, sex, location of arrest, and witnessed status), (**C**) adjusted for patient factors and neighborhood factors (income, education, urban/rural status) and (**D**) adjusted for patient factors, neighborhood factors, and interventions (bystander and first responder CPR and defibrillation). All analyses include an interaction between race and calendar year. The interaction is showed as a *P* value in the Figure. A *P* value <0.05 is considered statistically significant. CPR indicates cardiopulmonary resuscitation; and OHCA, out-of-hospital cardiac arrest.

and initial rhythm), neighborhood factors (income status, educational status and urban/rural), and modifiable factors (bystander and first responder CPR and defibrillation prior to EMS arrival). Importantly (3), when limiting the analysis to patients with initial shockable rhythm increased survival was observed for both Black and White patients. Overall, these findings suggest that the observed difference in survival between races could be related to both differences in non-modifiable pre-arrest factors as well as in more modifiable factors. Nonetheless, additional interventions may be needed to help increase survival for Black patients. Notably, the observed increase in survival only among shockable patients has also been reported among other patient groups (men versus women) and is an important issue to address since our current strategies may thus only benefit a minority of cardiac arrest patients.[22,23]

This study adds novel findings to understand the gap in outcomes between Black and White patients who suffer OHCA. Importantly, our findings could indicate that many different factors including general health risk factors and typically measured socioeconomic parameters and other than pre-hospital interventions may contribute to gaps in care and outcomes between Black and White patients. Differences in bystander interventions (CPR and defibrillation) according to race

have previously been observed with overall lower rates of bystander CPR and defibrillation in Black patients and also in neighborhoods with a higher proportion of Black inhabitants.[7,8,9,24] Importantly, our study found significant increases over time in both bystander CPR and first responder defibrillation in both Black and White patients indicating the initiatives made as part of the RACE-CARS program/HeartRescue Project in North Carolina[13,14] overall had a positive effect, irrespective of race. These results persisted even when adjusting for both important patient and neighborhood socioeconomic factors.

Even though we observed increased probability of return of spontaneous circulation in both patient groups from 2010 to 2014, as a likely result of the improved pre-hospital care, survival to discharge, as well as survival with favorable neurological outcome, only increased significantly in White patients, in both crude and adjusted analyses. Factors other than pre-hospital factors may partly explain why survival to discharge increased significantly in White patients and not in Black patients. For example, it could be the differential use of emergency coronary interventions, which is more common in White patients, that resulted in greater likelihood of White patients surviving, as well as other elements of post-resuscitation hospital care. Previous research has also suggested that racial disparities in survival could be a result of differences in both non-modifiable factors as age, sex, location of arrest, witnessed status and initial heart rhythm and in more modifiable factors as bystander and first responder CPR and defibrillation.[9] In relation to race socioeconomic effects are also often mentioned, and socioeconomic differences have earlier been found associated with both intervention and survival,[11,25] and have earlier been suggested to explain some of the racial differences in survival. Supporting this, we found that Black patients were more likely to have OHCA in neighborhoods with predominantly poorer or less educated residents. However, adjusting for all these factors (the non-modifiable factors, the modifiable factors, and the neighborhood socioeconomic factors) in our multivariable model did not change our findings, and survival was still observed to be lower and with limited change over time in Black patients compared to an increase for White patients. Thus, our results suggest that differences in socioeconomic factors do not fully explain racial differences in survival.

To investigate the observed differences further, we examined only patients with initial shockable rhythm given Black patients had lower rates of shockable rhythms—a finding in previous studies as well.[9,26] Importantly, when limiting the analysis to patients with a shockable rhythm, we observed an increase in survival in both Black and White patients. The increase in survival remained lower for Black patients compared to White patients and was not statistically significant, but the lack of significance may be due to a small sample size.

However, the lower rate of shockable rhythm seemed to be an important contributor to the observed overall lower survival for Black patients, since survival seemed to increase in both patient groups over time when including only shockable patients. Several factors may influence the likelihood of having an initial shockable heart rhythm and thereby improved survival. Factors as younger age, performed CPR and defibrillation,[27] including the availability of CPR-trained bystanders and nearby AEDs, the willingness or potential barriers to intervene and contact authorities[8,28] are all examples of factors that can affect the window for having a shockable heart rhythm by affecting time from collapse to call for help, to CPR and to contact 911/EMS. Another aspect is also the fact that more Black patients have their cardiac arrest in urban areas, where EMS is more likely to be first on scene compared with first responders which overall could be associated with a delay in interventions. Importantly, bystander interventions prior to EMS arrival increased for both groups and perhaps more targeted CPR training and AED availability including dispatch-assistance could potentially help the Black patients further.[29] Other factors that may also affect the observed difference in heart rhythm could be underlying physiological differences including potential severity of cardiac pathology, and genetic differences[30] that could affect the etiology of the cardiac arrest. Studies have shown that Black patients have a higher rate of sudden cardiac death,[9,26,31] electrocardiogram abnormalities,[32,33] left ventricular hypertrophy and cardiomyophathy.[34,35] This is supported by our finding of a higher incidence of cardiac arrests in Black patients per 100 000 inhabitants and that the lower rate of shockable rhythm in Black patients was observed even when restricting the analysis to witnessed arrests and arrests with bystander CPR. More research into potential reasons for lower rates of shockable heart rhythm among Black patients is warranted. Lastly and importantly, even though this study found a positive impact of the RACE-CARS program/HeartRescue interventions in North Carolina irrespective of race, future programs and research should be targeted minority communities to develop tailored interventions so more minorities can be reached for cardiac arrest education and more effectively can respond to cardiac arrest. It also includes studies on how to improve survival for all patients with an initial non-shockable heart rhythm. This is needed to improve overall survival, since only a minority of patients has an initial shockable heart rhythm for all demographic groups, and current strategies and treatments only seem to benefit those with an initial shockable heart rhythm.

Limitations

This study had several limitations of which the first is its observational design, where the relationships must be seen as associations and not causal effects. We pursued high-quality data with prospective and uniform data collection through the CARES registry following Utstein guidelines[18] and we only included data from counties with 100% enrollment, to reduce the risk of bias due to changes in reporting over time, as previously done.[14] There may be differences between the included and excluded counties, yet characteristics in the included counties are similar to other cardiac arrest populations, indicating some generalizability.[7-10] Another limitation is the reporting of patient race in the CARES registry that could lead to misclassification, since it is seldom reported by the patient, who is unable to self-report race when incapacitated, but is primarily based on provider assessment, or rarely by family if they are available and if they are asked to provide this information. We do not have further details on who reported race for each patient, which may add to imprecision. Additionally, this study was limited by the lack of important information on several factors that may influence outcome as for example patient socioeconomic factors, time for recognition of arrest and time from recognition to 911 call, however, these are practically impossible to obtain, as is the case in other cardiac arrest studies. Further, time to interventions (CPR and defibrillation), the quality of performed CPR, assistance from dispatchers including identification of arrest, as well as additional information on the receiving hospitals and the in-hospital care of the patients, etc. were also not available. We only included cardiac arrests of presumed cardiac etiology since the CARES registry in the current time period only required these cases to be captured (prior to 2013). From the beginning of 2013 the CARES registry began collecting cases of all non-traumatic etiologies. Including cases with other etiologies than presumed cardiac etiology or a further sub-specification of the cardiac etiology might have helped enlighten the interesting difference in for example initial shockable rhythm between Black and White patients.

CONCLUSIONS

After the RACE-CARS/HeartRescue quality improvement program, bystander CPR and first responder defibrillation increased for both Black and White patients, whereas survival overall only increased in White patients, also when adjusting for important patient-, cardiac arrest-related, and neighborhood socioeconomic factors. This indicates that the improvements work irrespective of race, but more work remains to be done to explain why survival to discharge only increased significantly in White patients. The lower initial shockable rhythm among Black patients could be an important contributor due to the observed improvement in survival in only shockable patients. Examining more factors influencing the underlying rhythm could be an important focus in future studies.

ARTICLE INFORMATION

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Affiliations

Duke Clinical Research Institute, Durham, NC (S.M., C.M.H., K.K., M.E.D., C.T., J.G.J., L.M., M.A.S., K.L.T., C.B.G.); Department of Cardiology, Copenhagen University Hospital Herlev and Gentofte, Hellerup, Denmark (S.M.); Emergency Medical Services Copenhagen, University of Copenhagen, Denmark (C.M.H.); Department of Cardiology, Nordsjaellands Hospital, Hillerød, Denmark (C.M.H., C.T.); Department of Cardiology, North Denmark Regional Hospital &, Aalborg University Hospital, Aalborg, Denmark (K.K.); Department of Sociology, Durham, NC (M.E.D.); Department of Population Health Sciences, Duke University, Durham, NC (M.E.D.); Department of Emergency Medicine, University of Colorado School of Medicine, Aurora, CO (C.S.); Carolinas Medical Center Charlotte, Charlotte, NC (D.A.P.); Emory University School of Medicine Atlanta, Atlanta, GA (B.M.); Rollins School of Public Health Atlanta, Atlanta, GA (B.M.); and Department of Emergency Medicine, Northwell Health, Hofstra Northwell School of Medicine at Hofstra University, Manhasset, NY (L.B.).

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Disclosures

None.

Supplementary Material

Figure S1–S5

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SUPPLEMENTAL MATERIAL

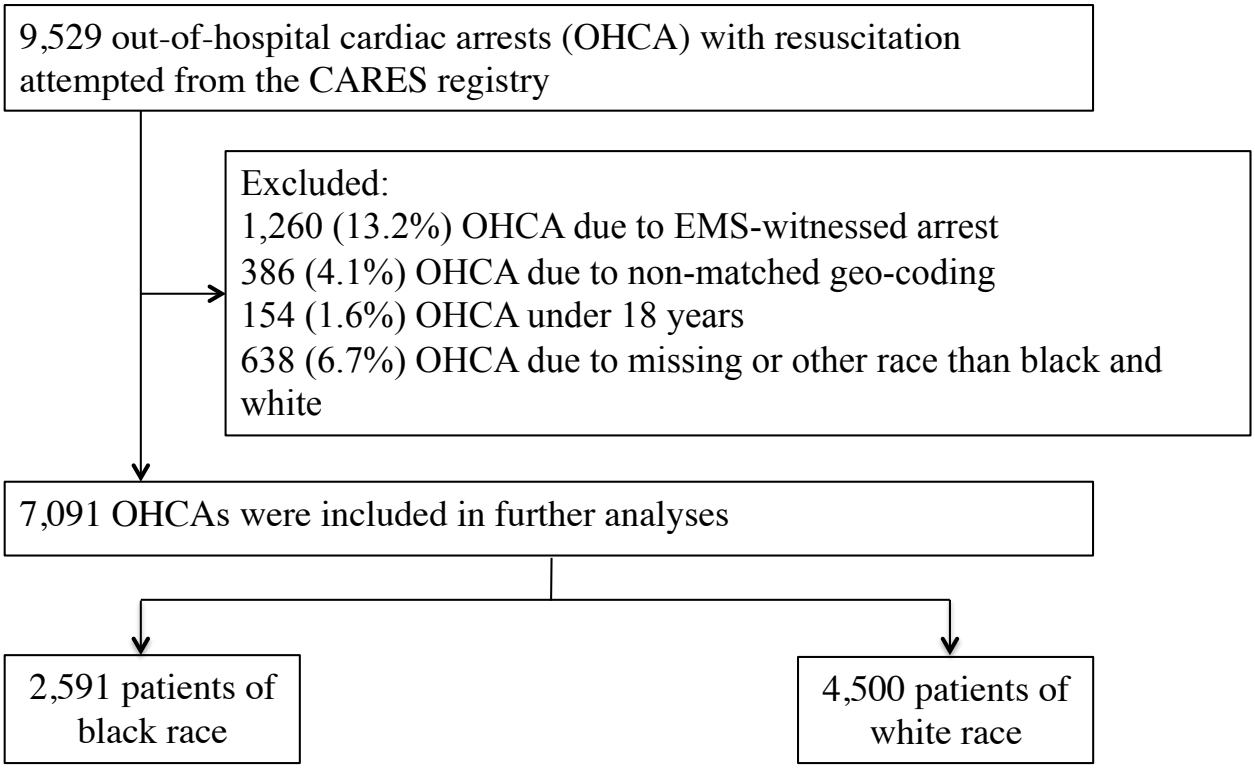

Figure S1, Patient selection process

Flowchart of the patient selection process

EMS, emergency medical services; OHCA, out-of-hospital cardiac arrest

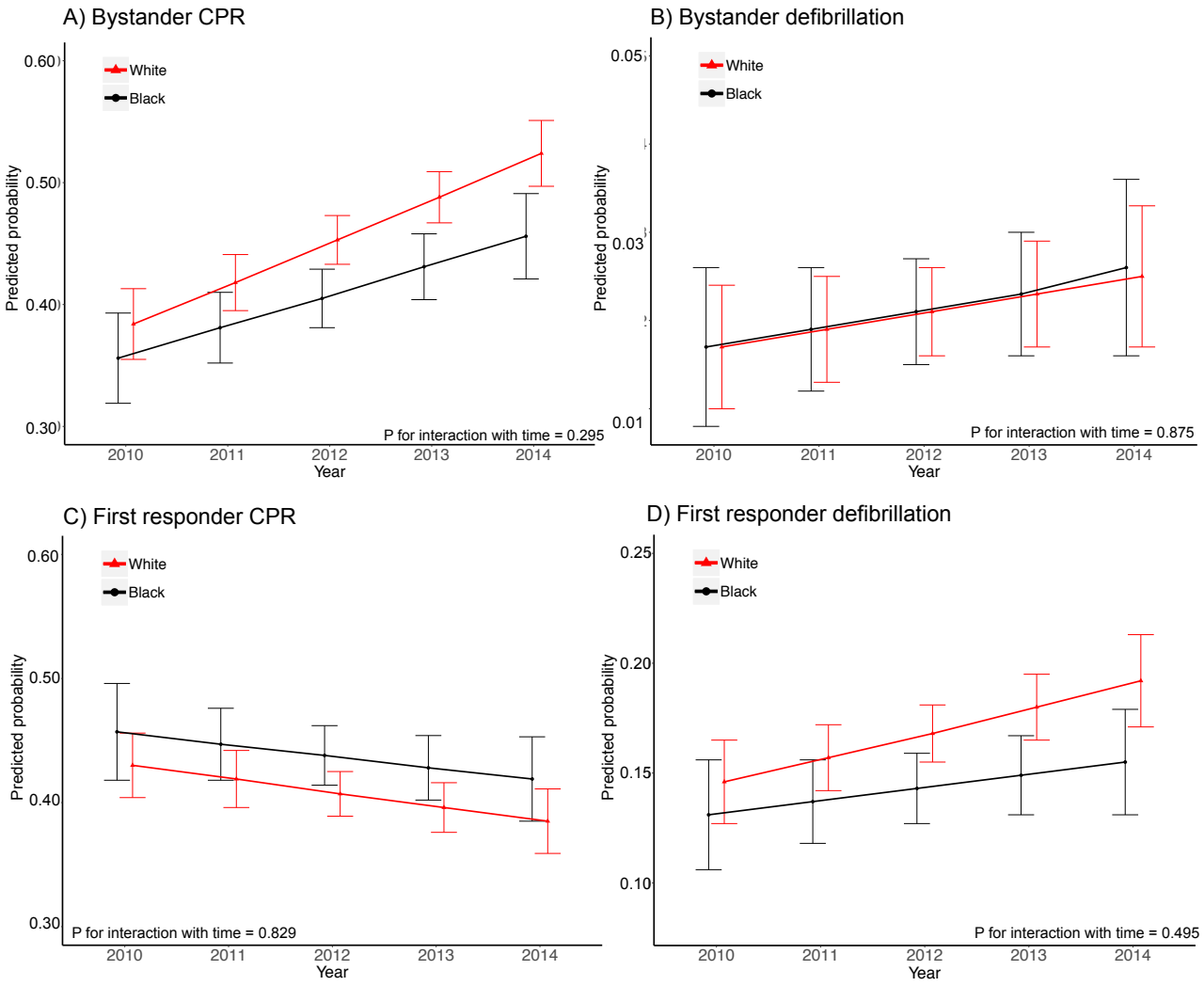

Figure S2, Unadjusted predicted probabilities of bystander and first responder CPR and defibrillation

Figure S2 shows the un-adjusted (crude) predicted probabilities as percentages with 95% confidence intervals from 2010 to 2014 for bystander CPR (A), bystander defibrillation (B), first responder CPR (C) and first responder defibrillation (D) in Black and White patients. The analyses include an interaction between race and calendar year. The interaction is showed as a p-value in the Figure. A p-value <0.05 is considered statistically significant.

CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest

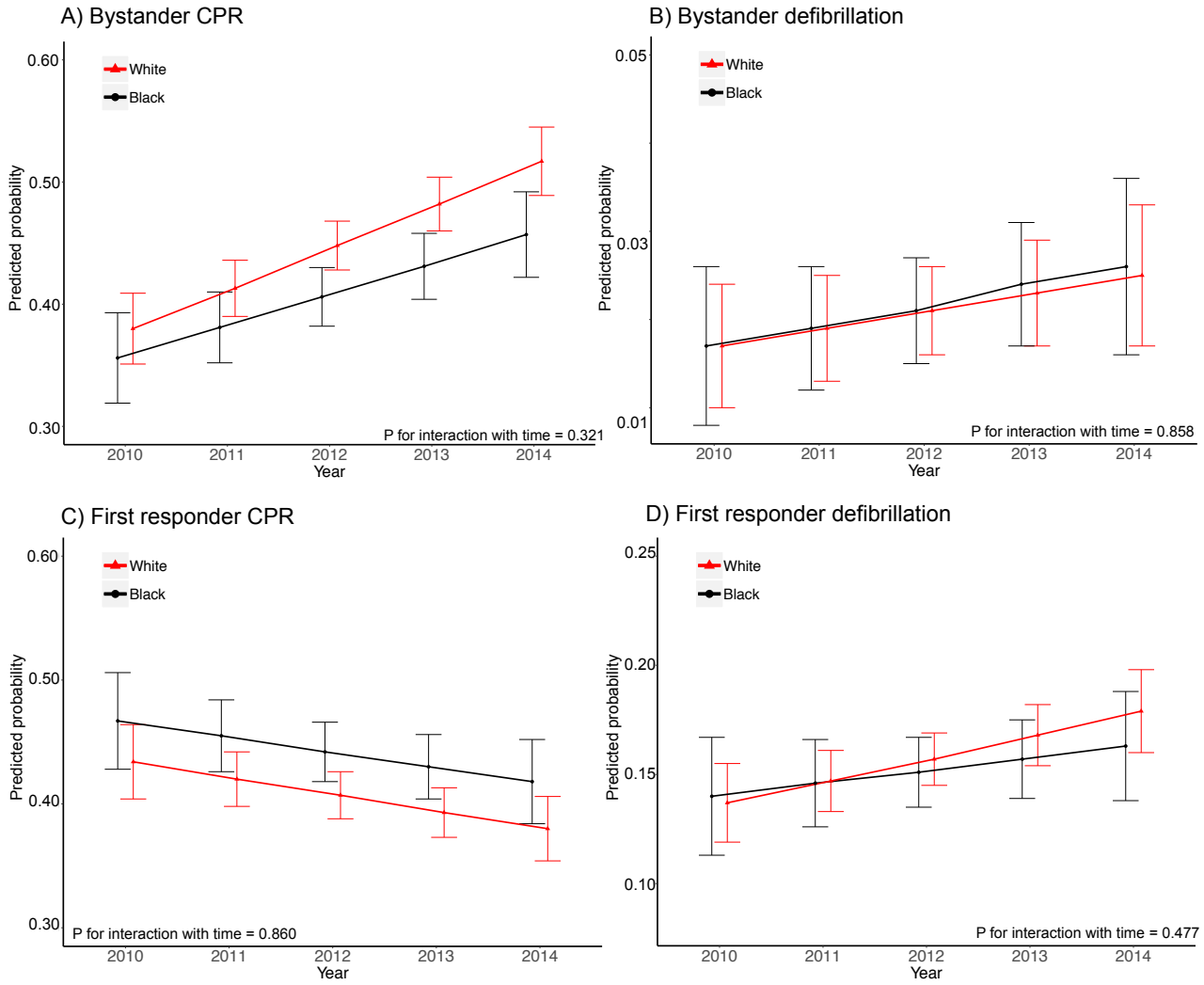

Figure S3, Predicted probabilities of bystander and first responder CPR and defibrillation adjusted for age, sex and neighborhood factors

Figure S3 shows the predicted probabilities as percentages with 95% confidence intervals from 2010 to 2014 for bystander CPR (A), bystander defibrillation (B), first responder CPR (C) and first responder defibrillation (D) in Black and White patients. The analyses were adjusted for age, sex and neighborhood factors (income, education and urban/rural status) and include an interaction between race and calendar year. The interaction is showed as a p-value in the Figure. A p-value <0.05 is considered statistically significant.

CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest

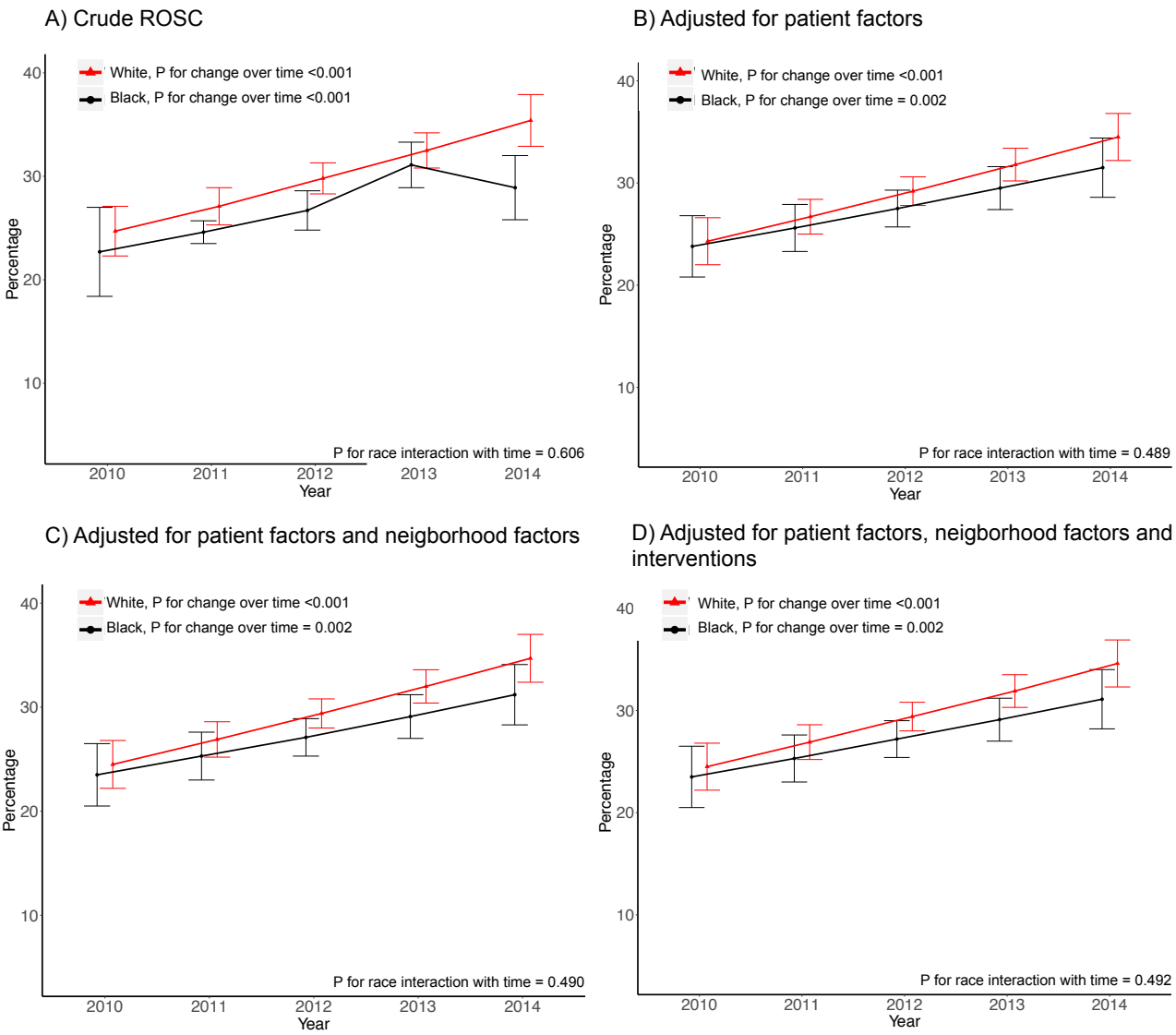

Figure S4, Predicted probabilities of return of spontaneous circulation

Figure S4 shows the predicted probabilities for return of spontaneous circulation after OHCA with 95% confidence intervals from 2010 to 2014 in Black and White patients. The Figure shows (A) a crude analysis, (B) adjusted for patient factors (age, sex, location of arrest and witnessed status), (C) adjusted for patient factors and neighborhood factors (income, education, urban/rural status) and (D) adjusted for patient factors, neighborhood factors and interventions (bystander and first responder CPR and defibrillation). All analyses include an interaction between race and calendar year. The interaction is showed as a p-value in the Figure. A p-value <0.05 is considered statistically significant.

CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest

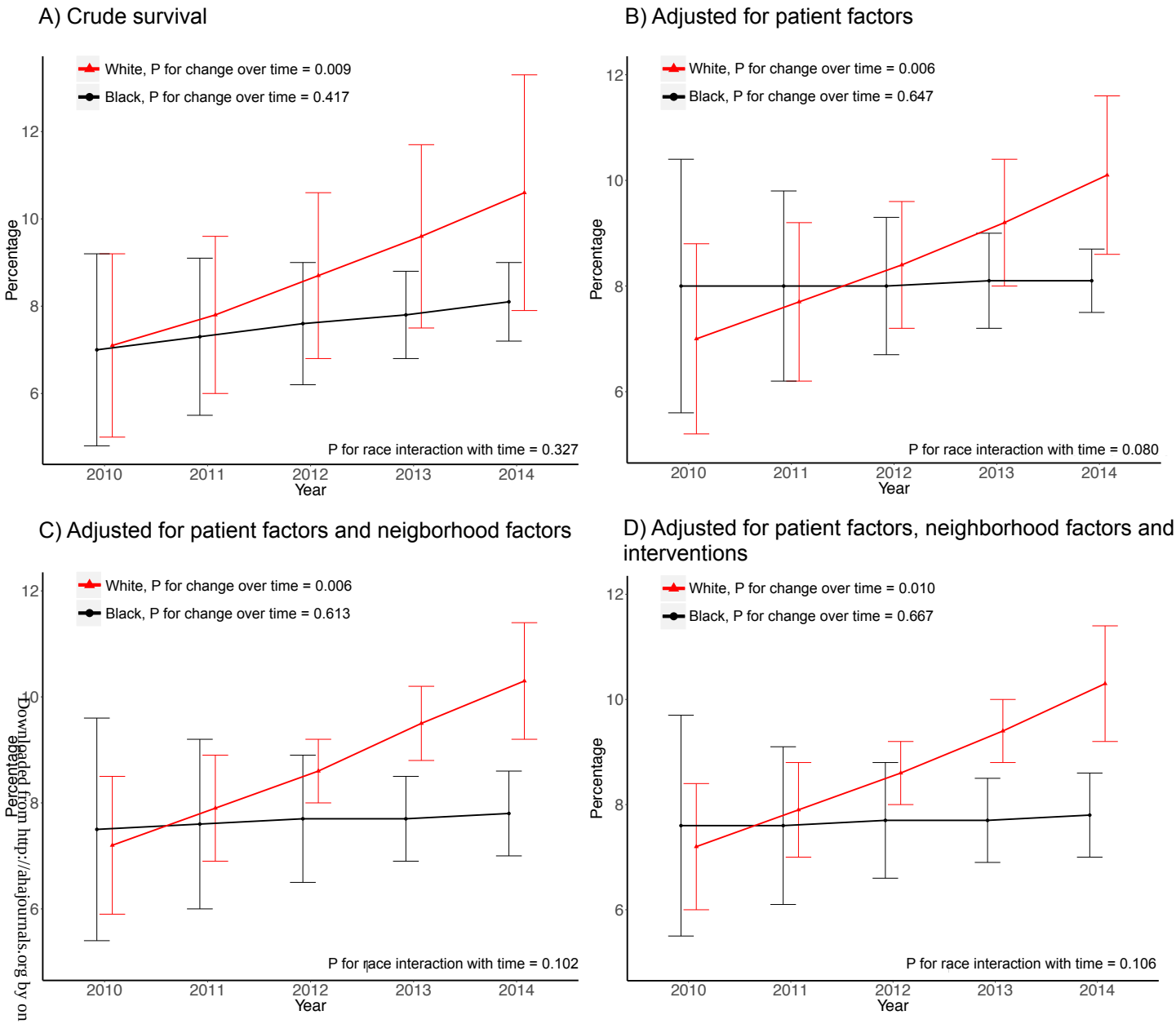

Figure S5, Predicted probabilities of survival with a favorable neurological outcome

Figure S5 shows the predicted probabilities for survival with a favorable neurological outcome with 95% confidence intervals from 2010 to 2014 in Black and White patients. The Figure shows (A) a crude analysis, (B) adjusted for patient factors (age, sex, location of arrest and witnessed status), (C) adjusted for patient factors and neighborhood factors (income, education, urban/rural status) and (D) adjusted for patient factors, neighborhood factors and

interventions (bystander and first responder CPR and defibrillation). All analyses include an interaction between race and calendar year. The interaction is showed as a p-value in the Figure. A p-value <0.05 is considered statistically significant.

CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest