Ethnic Differences in Sudden Cardiac Arrest

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Abstract

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Background: Some studies suggest that African Americans (AA) have a higher incidence of sudden cardiac arrest (SCA) and worse survival than European Americans (EA). Ethnic differences in the circumstances and outcomes of SCA have not been well explored and have yielded inconsistent results. We therefore examined ethnic differences in patient characteristics, medical morbidities, arrest circumstances, medical care, and outcomes among SCA cases of European, African, and Asian descent in Seattle, Washington.

Methods: Out of hospital arrests in the greater Seattle area were identified by paramedics between 1988 and 2009, as part of the Cardiac Arrest Blood Study (CABS) Repository. Out of hospital arrest cases due to non-cardiac etiology were excluded. Ethnicity was ascertained by paramedic incident reports, hospital medical records and death certificates. Cases were linked to hospitalization records and geographic information systems data. Logistic regression analysis was used to examine the outcomes of successful resuscitation and survival to hospital discharge in 3 ethnicities, with EA as the reference group. Multinomial logistic regression analysis was used to examine predictors of the three different presenting rhythms: ventricular fibrillation (VF), pulseless electrical activity (PEA) and asystole, using VF as the reference group.

Results: The cohort of SCA cases included 3551 EA, 440 AA, and 297 Asians (AS). AA cases were younger than the other two ethnic groups. On average, both AA and AS had lower education and lower income relative to EA (p<0.0001). Fewer AA had atrial fibrillation diagnosed during past hospitalizations (p<0.0001), but, along with AS, a larger proportion had previous diagnoses of hypertension, diabetes mellitus, and renal disease during hospitalizations compared with EA cases (p<0.0001). At the time of cardiac arrest, African and Asian-descent individuals were less likely to have a witnessed arrest or receive bystander CPR compared with European-descent SCA cases. AA were more likely to be found in PEA and AS were more likely to be found in asystole compared with EA cases. Resuscitation duration was the same in all 3 groups. Survival to hospital admission and discharge was similar in the 3 ethnicities (multivariate adjusted OR 1.10, 95% CI 0.79-1.54 for AA vs. EA, p=0.56; OR 1.33, 95% CI 0.86-2.05, p=0.20 for AS vs. EA). Moreover, among VF survivors, there was no statistically significant difference in the proportion of those who received coronary artery bypass graft (CABG) or implanted cardioverter defibrillator (ICD) prior to hospital discharge. Given the strong association of initial presenting rhythm with outcome, patient characteristics and clinical factors associated with VF, PEA, and asystole as presenting rhythm were explored in adjusted analyses. Compared with those presenting in VF, those presenting in PEA were more likely to be of African descent and less likely to receive bystander CPR (OR 1.54, 95% CI 1.15-2.07, p=0.004; OR 0.60, 95% CI 0.49-0.72, p<0.0001 respectively), and those in asystole were more likely to be of Asian descent (OR 1.53, 95% CI 1.10-2.13, p=0.01).

Conclusion: While other studies have shown higher mortality in AA than in EA individuals with SCA, in Seattle, with one of the country's most effective emergency

medical care systems, we did not detect a difference in survival between European-, African- and Asian-descent individuals. Nearly 25% of SCA cases of all 3 ethnicities that presented with VF survived to hospital discharge. There is, however, a difference by ethnicity in presenting rhythm, with more PEA among AA and more asystole among AS SCA cases.

INTRODUCTION

Sudden cardiac arrest (SCA) is a major public health problem accounting for approximately 424,000 deaths annually in the US [1]. Despite recent progress in treatment and prevention of coronary heart disease (CHD), and advances in cardiopulmonary resuscitation, SCA remains a leading cause of mortality due to its high fatality [2, 3]. Factors affecting survival from SCA have been thoroughly studied and include a lower burden of medical comorbidities, VF as presenting rhythm, public location of arrest witnessed arrest, and bystander CPR [4-10].

There is evidence that the burden of SCA affects ethnic groups disproportionately. Some studies suggest that African Americans (AA) have a higher incidence of SCA and poorer survival than European Americans (EA) [11-15]. These ethnic differences in SCA have not been thoroughly explored, nor have the results of the few studies been consistent [16-18]. While some studies posit that this increased SCA mortality is inherent to the ethnic group [14, 15], others report that it is in part due to socioeconomic status with those in the lower socioeconomic strata at higher risk of mortality [19]. Several have concluded that the survival differences between races is due to differences in cardiac arrest circumstances such as having a witnessed arrest, or receiving bystander CPR, as well as health care related factors such as the emergency medical services (EMS) response time [16-18, 20]. Additionally, it has been noted in some, but not all, studies that the presenting rhythm differs between the ethnicities, with a lower proportion of ventricular fibrillation (VF), a rhythm associated with better outcomes[21], in AA and Asians (AS) [14-18, 22]. Lastly, a study suggested that AA receive fewer proven lifesaving interventions post-SCA, such as coronary angioplasty, and implantable cardioverter defibrillator (ICD) implantation [23].

The discrepancies merit further investigation, not only to shed light on the complex pathophysiology of SCA, but also to identify potential health services differences and to improve management and prevention strategies. We examined a cohort of sudden cardiac arrest cases (3551 European Americans, 440 African Americans and 297 Asians) attended by paramedics in Seattle and King County from 1988-2009 in order to investigate the multiple factors that affect SCA outcomes including the characteristics of SCA cases, underlying medical morbidities, SCA circumstances such as presenting rhythm, and medical care such as duration of resuscitation.

METHODS

Study Population

We studied cases of out of hospital arrest attended by paramedics in Seattle and King County, Washington between 1988 and 2009 as part of the Cardiac Arrest Blood Study (CABS). SCA in our study was defined as a sudden pulseless condition presumed due to an arrhythmia in the absence of any evidence of non-cardiac cause of the arrest. From 6454 out-of-hospital arrest cases collected, we excluded cases with an evident acute morbidity that could account for the arrest, such as drug overdose, stroke, aortic aneurysm rupture, other acute bleeding, acute respiratory failure, or trauma, as well as cases with chronic terminal illnesses including terminal cancer or end stage liver disease (n=1955, Supplementary Figure 1). Ethnicity was ascertained by paramedic incident reports, hospital medical records and death certificates, and we limited our analysis to three ethnic groups: EA (n=3551), AA (n=440), and AS (n=297). We excluded those with unknown ethnicity or other ethnic groups from our study (n=211).

Data were obtained from: 1) emergency medical service (EMS) incident reports, available for all cases; 2) post-arrest hospitalization data from Medic One (EMS foundation in Seattle), available for 555 cases with VF; 3) the Washington State Comprehensive Hospital Abstract Reporting System (CHARS) database of hospital discharge diagnoses, available for 2720; and 4) Geographic Information Systems (GIS) data for socioeconomic variables, available for 3630 (Supplementary Figure 1).

Covariate Definitions

Socioeconomic information was based on US census tract estimates for the zip code of residence from 1999 for each case, and included median household income, proportion of residents under the 1999 threshold for poverty in Seattle, WA, and the proportion of residents that did not graduate from high school.

Sixty eight percent of our cases had prior hospitalization records in CHARS from 1988-2009 from which we obtained information about past discharge diagnoses of myocardial infarction, congestive heart failure, ischemic or hemorrhagic stroke, atrial fibrillation, renal failure, pulmonary disease, as well as admissions for the following procedures: coronary angiogram, coronary angioplasty, and coronary artery bypass graft (CABG) surgery. Those admitted without these diagnoses/procedures, and those without any record of hospital admissions, were regarded as not having a history of these conditions.

Additionally, the diagnoses of hypertension, diabetes, and coronary artery disease were examined in a subgroup analysis restricted to the 68% of cases with hospital records (n=2720), to avoid the assumption that people for whom hospitalization data were missing are free of these three conditions. Coronary artery disease was defined as the presence of an ICD9 codes for prior acute MI, subacute ischemic heart disease, old MI, angina pectoris, other forms of chronic ischemic heart disease, ill-defined and complications of heart disease, or atherosclerosis.

The presenting rhythm was the first observed rhythm when EMS personnel applied an automatic external defibrillator (AED). Our analysis includes all presenting rhythms: ventricular fibrillation (VF), pulseless electrical activity (PEA) and asystole. The very few ventricular tachycardia cases were included in the VF category. Complete heart block was included in the PEA group. Public location of arrest was defined as an indoor or outdoor public location where others could have witnessed the arrest. Bystander CPR was receipt of CPR from a lay person, not EMS personnel. 911 call delay was extracted from incident reports when EMS personnel noted that there was evidence of delay. EMS response time was measured from dispatch time to arrival on scene, not to the initiation of CPR. Resuscitation duration was measured from the initiation of CPR until either cessation of resuscitation or arrival at the hospital. Post event hospitalization records, available mostly on VF cases, provided data on post SCA medical services and diagnosis codes.

Outcomes Definitions

Resuscitation was defined as survival to hospital admission; cases that expired in the field or the Emergency Room were considered not to have been successfully resuscitated. Survival was defined as discharge from the hospital alive.

Statistical Analysis

For unadjusted analyses, we compared demographic characteristics, inpatient medical history, and SCA circumstances among three ethnic categories using Pearson chi2 for categorical/binary variables, and ANOVA for continuous variables.

To evaluate the association of duration of resuscitation with the outcomes of successful resuscitation and survival, we first stratified by the presenting rhythm (VF, PEA, asystole). For each rhythm and each outcome, we built logistic regression models with duration of resuscitation as the independent variable and sequential adjustment for covariates. We included age and gender in Model 1, added ethnicity in Model 2, and added SCA circumstances and prior inpatient medical history covariates in Model 3.

For adjusted analysis of the association of ethnicity with outcomes of SCA, we used logistic regression to obtain our point estimates, odds ratio (OR), 95% confidence intervals and p value. In model 1 we adjusted for age and gender only, in model 2 we added presenting rhythm as a covariate, and in model 3 we used the additional covariates we had chosen *a priori* that are associated with SCA outcome based on previous published literature[7, 21], specifically: location of arrest, witnessed arrest, bystander CPR, EMS response time, as well as prior inpatient medical morbidities available on all our cases (myocardial infarction, congestive heart failure, stroke, atrial fibrillation, renal failure, lung disease). In all models, EA served as the comparison group.

Given the strong association of presenting rhythm with our outcome, we also performed multinomial logistic regression of the predictors of the three different presenting rhythms, with ventricular fibrillation as the reference group, generating the ratio of ORs as our point estimate, 95% CI, and p-value. As a secondary analysis, we created a second multinomial logistic regression model on the predictors of presenting rhythm limited to the subgroup of cases with hospitalization records to evaluate the predictive value of prior medical history of hypertension, diabetes mellitus and coronary artery disease.

RESULTS

Demographic characteristics, prior medical comorbidites and SCA circumstances

The cohort of SCA cases included 3551 EA, 440 AA, and 270 AS. On average, AA were younger than the two other ethnic groups, and, on average, both AA and AS had lower education and lower income than EA (**Table1**).

We examined ethnic differences in comorbidities that required hospitalization or that occurred during a prior hospitalization among our SCA cases (**Table 2**). AA had the fewest proportion of cases hospitalized with atrial fibrillation. AA and AS had a larger proportion of cases with hypertension, diabetes mellitus, and end-stage renal disease during a previous hospitalization compared with EA ($p<0.0001$). However there was little or no difference in the proportion hospitalized with CHD diagnoses or procedures among the 3 ethnic groups.

We then examined the differences in the circumstances surrounding the SCA event (**Table 3**). At the time of cardiac arrest, African and Asian-descent individuals were less likely to be found in VF compared with European-descent SCA cases (53% of EA, 46% of AA, and 41% of AS were found in VF). AA were the most likely to be found in PEA (21%), while Asians were the most likely to be found in asystole (41%). Additionally, AA were the least likely to receive bystander CPR (41% vs. 51% in EA and 46% in AS), and AS were the least likely to have a witnessed arrest (46% vs. 58% in EA and 52% in AA).

Acute care during SCA and post-resuscitation care

There were no statistically significant differences in health care delivery among the 3 ethnic groups; they received a similar number of AED shocks for VF, and drugs for each separate rhythm (**Table 3**), though the response time was shorter for AA and AS than for EA. We also examined duration of resuscitation for each rhythm, and there was no ethnic difference (**Table 4**). A similar trend was noted in medical care delivered to all 3 groups after their hospitalization with SCA (**Table 5**); among VF cases, all three ethnicities had similar rates of coronary catheterization (38% vs. 46% in EA, 35% in AS), and while we only had data on 77 EA, 16 AA, and 10 AS, we found no difference in the implementation of hypothermia. In VF survivors, a similar proportion had CABG (12% vs. 13% in EA and 7% in AS) and implanted cardioverter defibrillator (ICD) prior to hospital discharge (EA 34%, AA 40%, AS 24%). The only significant difference noted was in the rate of coronary angioplasty, which was lowest in AA (1.7% vs. 15% in EA, 16% in AS).

Outcomes

Association of Ethnicity with Outcomes

In unadjusted analyses, there was no difference in resuscitation and survival among the three ethnic groups when stratified by presenting rhythm, and nearly 25% of ventricular fibrillation cases survived to hospital discharge in all three ethnic groups (**Table 6**). Accounting for different SCA factors did not alter the lack of association of ethnicity with these outcomes (**Supplemental Table 1**). However, presenting rhythm was strongly associated with both resuscitation and survival, with better outcomes for those presenting in VF than for PEA or asystole.

Association of patient characteristics and arrest circumstances with presenting Rhythm

We examined patient characteristics and arrest circumstances associated with presenting rhythms of VF, PEA, and asystole (**Table 7 and Supplemental Table 2**). Compared with VF cases, older age was more common in cases presenting with PEA, but not in those presenting with asystole. Female gender, non-public location of arrest, lung disease and hypertension were more common in cases presenting with PEA and asystole relative to cases presenting in VF. Moreover, in the multivariable analysis and compared to VF as a presenting rhythm, those presenting in PEA were more likely to be of African descent and to receive less bystander CPR (OR 1.54, 95% CI 1.15-2.07, p=0.004; OR 0.60, 95% CI 0.49-0.72, p<0.0001 respectively), and those in asystole were more likely to be of Asian descent (OR 1.53, 95% CI 1.10-2.13, p=0.01), have an unwitnessed arrest, have longer response time, and have had atrial fibrillation or renal failure on a prior hospitalization. **Supplemental Tables 3 and 4** examines these associations with nonshockable rhythms as the reference group (PEA and asystole combined).

Association of Duration of Resuscitation with Outcomes

In asystole, longer duration of resuscitation was associated with improved survival after adjusting for patient characteristics, SCA circumstances, and prior medical comorbidities (OR 1.05, 95% CI 1.02-1.08, p<0.0001), while the opposite trend was seen when VF was the presenting rhythm (OR 0.97, 95% CI 0.97-0.98, p<0.0001). While longer resuscitation times improved chances of admission to the hospital, it was not associated with survival to hospital discharge for those presenting in PEA (**Table 8**).

DISCUSSION

Our study showed no ethnic difference in successful resuscitation in the field or survival to hospital discharge, despite AA and AS having lower socioeconomic status on average, and more unfavorable SCA circumstances, including presenting rhythm. While lack of sufficient power to detect a difference in outcome is a possibility, the finding of no difference may be due to the study being set in Seattle, WA, with one of the country's most effective emergency medical care systems [24]. Such finding is important in suggesting that with optimal pre-hospital care, outcomes of SCA among ethnic groups can be the same despite underlying disparities in some risk factors.

Seattle and King County were among the first locations to implement a paramedic system, Medic One, in 1969. Survival following out of hospital cardiac arrest improved after the implementation of Medic One [25], and the area currently has one of the highest survival rates for SCA [24], suggesting that the rigorous training, careful quality of care reviews and outcomes monitoring is highly effective. Our study setting in Seattle is an advantage as it minimizes the effect of inadequate or inconsistent pre-hospital care as a factor in ethnic differences in SCA outcomes. Additionally, the Cardiac Arrest Blood Study is a case-control study where the out of hospital arrest cases were rigorously reviewed and adjudicated. Only cases adjudicated to have a cardiac etiology were included in this study, to allow for a more uniform phenotype and exclude any misclassification bias from arrest cases that were non-cardiac in etiology. This is also the first study to compare characteristics and outcomes for AS, in addition to AA and EA.

The ethnic differences we noted in patient characteristics and SCA circumstances were similar to those previously published for AA relative to EA [14-18, 20, 22, 26] . AA had lower average socioeconomic status, and a lower proportion of bystander CPR and witnessed arrests, relative to EA. Moreover, the proportion of AA and AS SCA cases presenting in VF was lower than for EA, corroborating findings of other studies [14, 16, 17, 22]. Thus, we did not detect ethnicity-specific differences in characteristics or circumstances of arrest between our study population and the populations of other studies to explain the difference in study findings.

Notably, we did not find any evidence of ethnic disparities in health care delivery with similar duration of resuscitation, AED shocks and drug delivery. The EMS response time was in fact shorter in AA and AS relative to EA, though response time is measured from EMS dispatch to arrival on scene and does not take into account the time from the arrest until 911 is called, nor does it consider the time it takes to reach the patient's side. Additionally, in contrast to a prior published report, there was no statistically significant ethnic difference in either coronary artery bypass graft (CABG) surgery or ICD implantation amongst VF survivors [23].

Presenting rhythm was a key predictor of outcome, with improved outcomes for VF relative to PEA and asystole. Both AA and AS had a lower proportion with VF as the presenting rhythm, compared with EA. The presenting rhythm was PEA in a greater proportion of AA than EA, confirming the findings of Teodorescu and Galea [17, 27], and was asystole in a greater proportion of AS, confirming the findings of Peckova et al [28]. Our study demonstrates that ethnicity was a strong predictor of presenting rhythm in SCA cases; the association of AA with PEA remained even after adjustment for comorbidities and circumstances surrounding SCA that influence rhythm, such as un-witnessed arrest. And while the disproportional amount of renal disease, lung disease, hypertension, and diabetes mellitus in both AA and AS might partially explain this discrepancy, further exploration is needed with a larger sample size and more thoroughly ascertained past medical history to fully understand this difference in rhythm presentation.

Though Goldberger et al [29] showed that longer duration of resuscitation in in-hospital cardiac arrests improved survival, we did not find a similar overall trend in out-of-hospital cardiac arrests. A strong association of longer duration of resuscitation was found with survival in those presenting with asystole, while the opposite was noted in VF SCA survivors. It is unclear whether this is due to VF SCA cases that survived having fewer comorbidities, thus requiring shorter resuscitation efforts, while asystole cases generally have a larger burden of comorbidities. In PEA, there was no trend noted for duration of resuscitation in relation to survival. Duration of resuscitation certainly merits further study, including examining the burden of comorbidities among survivors vs non-survivors.

There were several limitations to this study. First, while Seattle's effective EMS care is a strength; it is also a limitation, as it affects the generalizability of our study to other locations in the country. Our study's sample size, albeit large relative to some of the published studies of ethnic differences for African Americans, is still limited. We also lacked individual income, education, and poverty data, and had to instead use geocoding derived residence income from 1999 from GIS data. The ethnic disparities in medical morbidities might be underestimated in AA or AS, who likely have less access to health care, leading to inaccurate classification. However despite that possibility, we observed a higher proportion with renal disease, lung disease, hypertension and diabetes in AA and/or AS than in EA. We did not have uniform access to outpatient medical records to ascertain the medical comorbidities in our cases, which could have biased our assessment of medical history. Also, we only had data on post event medical care in hospitalized VF cases; hence we couldn't measure any differences in care in PEA and asystole cases.

Moreover, It would have strengthened our analysis if we uniformly had access to autopsy data for the SCA cases, as it would have shed more light on the pathophysiology underlying the ethnic differences in presenting rhythms of SCA. We only had limited autopsy reports, and not autopsy performed specifically for our study, such as the ones performed by Dr. Renu Virmani [11]. We also lack EKG and echocardiography data prior to arrest, which would have added more information on certain SCA risk factors such as QTc or left ventricular hypertrophy.

While other studies have shown higher mortality in AA than in EA post cardiac arrest, in Seattle, with one of the most effective emergency medical care systems, there was no statistically significant difference in survival between European-, African- and Asian-descent individuals despite underlying unfavorable characteristics and SCA circumstances in AA and AS. However, it is possible that our finding is due to lack of power to detect differences in outcome among the 3 ethnic groups. There is a difference by ethnicity in presenting rhythm, one of the strongest predictors of survival, with more PEA among AA, and more asystole among AS SCA cases. Further investigation is needed of the underlying pathophysiology of SCA cases, including autopsy data, and more detailed medical history, including EKG and echocardiographic data.

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TABLE 1: Demographic Characteristics of SCA Patients in Seattle/King County, 1988-2009

	European Am. N=3551	African Am. N=440	Asians N=297	P**
Age (in yrs) mean(SD)	68.2 (13.4)	63.4 (13.5)	66.8 (13.9)	<0.0001
Men n(%)	2581 (72.7)	298 (67.7)	202 (68.0)	0.03
	N=2953	N=409	N=258	P**
Median Household Income* Mean $ (SD)	54,395 (17,347)	43,869 (14,716)	45,190 (15,411)	<0.0001
% Below Federal Poverty limit* mean%(SD)	8.8 (6.6)	15.6 (9.2)	13.9 (9.5)	<0.0001
% With Education <12th Grade* mean%(SD)	9.2 (7.5)	18.8 (9.6)	20.2 (11)	<0.0001

*Based on US census 1999 estimates from zip code of residence

**p values are derived from ANOVA for continuous variables and Pearson chi2 for binary variables.

TABLE 2: Hospitalization Records of SCA Patients Before SCA

	European Am. N=3551	African Am. N=440	Asians N=297	P*
Prior hospitalization with: n(%)				
DIAGNOSES				
Myocardial Infarction ~	513 (14.5)	57 (13.0)	41 (13.8)	0.68
Stroke	292 (8.2)	41 (9.3)	21 (7.1)	0.55
Congestive Heart Failure	750 (21.1)	107 (24.3)	67 (22.6)	0.28
Atrial Fibrillation	534 (15.0)	31 (7.1)	37 (12.5)	<0.0001
End-Stage Renal Disease	143 (4.0)	41 (9.3)	26 (8.8)	<0.0001
Chronic Pulmonary Ds.	422 (11.9)	66 (15.0)	28 (9.4)	0.06
PROCEDURES				
Coronary angiogram	348 (9.8)	43 (9.8)	28 (9.4)	0.98
Coronary Angioplasty	163 (4.6)	16 (3.6)	17 (5.7)	0.41
Coronary Artery Bypass	188 (5.3)	11 (2.5)	12 (4.0)	0.03
Among those hospitalized, prior hospitalization with: n(%)	European Am. N=2264	African Am. N=283	Asians N=173	P*
Hypertension	765 (33.8)	155 (54.8)	72 (41.6)	<0.0001
Diabetes Mellitus	460 (20.3)	89 (31.5)	62 (35.8)	<0.0001
Coronary Artery Disease~	927 (41.0)	111 (39.2)	72 (41.6)	0.84

*P-value obtained with pearson chi-2 test for categorical and binary variables and ANOVA for continuous variables.

~Myocardial infarction includes ICD9 code for acute myocardial infarction (410.x); Coronary artery disease includes ICD9 codes for acute MI, subacute ischemic heart disease, old MI, angina pectoris, other forms of chronic ischemic heart disease, ill-defined and complications of heart disease, and atherosclerosis

TABLE 3: Ethnic Differences in Sudden Cardiac Arrest Event Characteristics

	European Am. N=3551	African Am N=440	Asians N=297	P*
Presenting Rhythm n %				<0.0001
Ventricular fibrillation	1895 (53.4)	203 (46.1)	121 (40.7)	
Pulseless electrical activity	590 (16.6)	92 (20.9)	54 (18.2)	
Asystole	1066 (30.0)	145 (33.0)	122 (41.1)	
Arrest Location				0.09
Public	893 (25.6)	94 (22.0)	67 (23.0)	
Residence	2379 (68.3)	306 (71.5)	209 (71.8)	
Clinic	46 (1.3)	7 (1.6)	8 (2.8)	
Nursing home	166 (4.8)	21 (5.0)	7 (2.4)	
Witnessed Arrest	2045 (57.6)	229 (52.1)	137 (46.1)	<0.0001
Bystander CPR	1806 (50.9)	182 (41.4)	140 (47.1)	0.001
911 call delay**	108 (5.6)	10 (4.9)	8 (5.9)	0.9
EMS response time in min				
BLS or ACLS unit	5.18 (SD=2.0)	4.75 (SD=1.6)	4.85 (SD=1.6)	<0.0001
ACLS unit	9.19 (SD=4.2)	8.45 (SD=3.8)	8.77 (SD=3.8)	0.0003

BLS: Basic Life Support; ACLS: Advanced Cardiovascular Life Support
*P values are from chi2 tests for categorical variables and ANOVA for continuous variable
**Data available on 1931 EA, 206 AA, 136 AS.

TABLE 4: Ethnic Differences in Sudden Cardiac Arrest Therapy, by Presenting Rhythm

	European Am.			African-Am			Asians		
	VF n=1895	PEA n=590	Asys n=1066	VF n=203	PEA n=92	Asys n=145	VF n=121	PEA n=54	Asys n=122
In the field:									
Shocks delivered for any VF, mean (SD)	5.5 (5.0)	1.3 (2.2)	0.6 (1.7)	5.2 (4.4)	1.7 (2.3)	0.7 (1.6)	5.6 (5.1)	1.3 (2.1)	0.5 (1.7)
Drugs delivered, %									
Epinephrine	81	92	85	84	95	99	80	94	88
Lidocaine	76	31	7	73	35	18	79	26	5
Bicarbonate	69	80	64	74	85	80	69	89	68
Atropine	36	56	40	38	55	44	38	45	34
Resuscitation duration min (SD)									
Died in Field	47 (17)	42 (15)	31 (14)	45 (17)	43(15)	32(15)	50 (22)	45 (12)	30 (12)
Died in Hospital	51 (16)	49 (15)	50 (11)	45 (8)	49 (12)	49 (13)	50 (17)	44 (14)	44 (11)
Survived to hospital discharge	43 (14)	45 (14)	59 (21)	41 (13)	40 (17)	27 (-)**	45 (12)	_	53 (10)

Data displayed as mean (SD) for shocks delivered and resuscitation duration, and % for drugs delivered.
*Comparison of all different therapies amongst races were performed and none were statistically significant.
**no SD since data available on one patient only

TABLE 5: Among patients with Ventricular Fibrillation, Ethnic Differences in Post-Resuscitation Care

	European Am	African Am	Asian	P*
Acute Care**	n=463	n=58	n=37	
Cardiac Catheterization	210(46)	22 (37.9)	13 (35.1)	0.28
Coronary Angioplasty	68 (14.8)	1 (1.7)	6 (16.2)	0.02
Subacute Care***	n=351	n=43	n=28	
CABG	44 (12.6)	5 (11.6)	2 (7.1)	0.69
ICD	118 (33.6)	17 (40.0)	7 (24.1)	0.40
PPM	7 (2.0)	1 (2.3)	1 (3.6)	0.90

*P value is Pearson chi2 derived

**Data only collected on most VF survivors from 1988-1998, then broadened to include some non-survivors from 1999-2007.

***Subacute care category is limited to VF survivors.

TABLE 6: Unadjusted Proportions with Successful Resuscitation in the Field and Survival to Hospital Discharge, Stratified by Presenting Rhythm and Race

	European Am	African Am.	Asian	*p
VF	n=1895	n=203	n=121	
Resuscitation n%	896 (47.3)	82 (40.4)	63 (52.1)	0.09
Survival n%	444 (23.4)	52 (25.6)	35 (28.9)	0.33
PEA	n=590	n=92	n=54	
Resuscitation n%	123 (20.9)	19 (20.7)	14 (25.9)	0.68
Survival n%	23(4.0)	5(5.4)	0	0.25
Asystole	n=1066	n=145	n=122	
Resuscitation n%	115 (10.8)	22 (15.2)	11 (9.0)	0.22
Survival n%	5(0.5)	1(0.7)	3 (2.5)	0.04

* Pearson chi2 derived p value

TABLE 7: Predictors of Presenting Rhythm from a single multinomial logistic regression model including all characteristics (ventricular fibrillation as reference).

	Ventricular Fibrillation		Pulseless electrical activity					Asystole				
	n	% or m (SD)	n	% or m (SD)	OR*	95%CI	p	n	% or m (SD)	OR*	95%CI	p
Demographic characteristics												
Age (year) mean(SD)	2168	66 (14)	684	72 (12)	1.03	1.02-1.04	<0.0001	1272	68 (14)	1.01	0.99-1.01	0.09
Gender (M)	2219	79	736	64	0.70	0.57-0.86	0.001	1333	65	0.64	0.53-0.77	<0.0001
Race (Ref: EA)	1895	85	590	80				1066	80			
African Am.	203	9	92	13	1.54	1.15-2.07	0.004	145	11	1.12	0.84-1.49	0.43
Asian	121	6	54	7	1.54	1.07-2.22	0.02	122	9	1.53	1.10-2.13	0.01
SCA characteristics												
Location (Ref:Public)	799	37	110	15				145	11			
Residence	1292	59	528	73	2.11	1.66-2.67	<0.0001	1074	83	3.57	2.86-4.46	<0.0001
NH	53	2	65	9	7.29	4.52-11.8	<0.0001	76	6	4.41	2.67-7.29	<0.0001
Clinic	39	2	18	3	3.21	1.69-6.08	<0.0001	4	<1	0.75	0.22-2.56	0.65
Witnessed (Y)	1624	73	487	66	0.80	0.66-0.98	0.03	300	23	0.11	0.10-0.14	<0.0001
Bystander CPR (Y)	1204	54	300	41	0.60	0.49-0.72	<0.0001	624	47	0.89	0.75-1.05	0.17
Response Time (min) mean(SD)	2202	5 (2)	729	5 (2)	1.05	0.99-1.10	0.06	1322	5 (2)	1.07	1.03-1.12	0.001
Prior Inpatient diagnoses												
MI	345	16	101	14	0.82	0.61-1.09	0.17	165	12	0.80	0.61-1.04	0.09
CHF	475	21	169	23	0.77	0.59-1.01	0.06	280	21	0.90	0.70-1.13	0.33
CVA	185	8	61	8	0.65	0.46-0.93	0.02	108	8	0.83	0.61-1.12	0.22
Atrial fibrillation	335	15	104	14	0.72	0.53-0.98	0.04	163	12	0.62	0.47-0.83	0.001
Renal Failure	78	4	45	6	1.58	1.01-2.47	0.04	87	7	1.83	1.23-2.74	0.003
Lung Disease	228	10	110	15	1.50	1.12-2.00	0.006	178	13	1.35	1.02-1.77	0.03

Data presented as % except for continuous variables, which are presented as mean (SD)
*OR: The ratio of two odds ratios. The point estimate, 95% CI and p value are obtained with a multinomial logistic regression model with above covariates.

TABLE 8: Unadjusted and Adjusted Odds Ratios for the association of duration of CPR (in minutes) with the outcomes of Resuscitation in the Field and Survival to Hospital Discharge, stratified by Presenting Rhythm.

	VF n= 2219			PEA n=736			Asystole n=1333		
Resuscitation									
Unadjusted	1.00	0.99-1.00	0.73	1.02	1.01-1.03	<0.0001	1.08	1.05-1.09	<0.0001
Model 1*	1.00	0.99-1.00	0.96	1.02	1.01-1.03	0.001	1.08	1.05-1.09	<0.0001
Model 2*	0.99	0.99-1.00	0.95	1.02	1.00-1.03	0.001	1.08	1.05-1.09	<0.0001
Model 3 *	0.99	0.99-1.01	0.99	1.02	1.00-1.04	0.002	1.07	1.04-1.10	<0.0001
Survival									
Unadjusted	0.97	0.97-0.98	<0.0001	1.00	0.98-1.02	0.75	1.04	1.02-1.05	<0.0001
Model 1*	0.97	0.97-0.98	<0.0001	1.00	0.98-1.03	0.93	1.04	1.02-1.06	<0.0001
Model 2*	0.97	0.97-0.98	<0.0001	1.00	0.98-1.03	0.87	1.04	1.02-1.06	<0.0001
Model 3 *	0.97	0.97-0.98	<0.0001	1.00	0.97-1.03	0.83	1.05	1.02-1.08	<0.0001

*Model 1: adjusted for age and gender.
*Model 2: adjusted for age, gender and ethnicity.
*Model 3: adjusted for age, gender, ethnicity, and covariates: location of arrest, witnessed arrest, bystander CPR, EMS response time, comorbidities, (MI, CHF, CVA, Afib, renal failure, lung disease), available in all cases. Prior diagnoses of hypertension, diabetes mellitus and coronary artery disease are not included in this model, as data only available on 2720 of 4288 of cases.

SUPPLEMENTARY TABLE 1: Unadjusted and Adjusted Odds Ratios for Resuscitation in the Field and Survival to Hospital Discharge in African Americans and Asians relative to European Americans

	European Am. n=3551	African Am. n=440			Asian n=297		
Resuscitation	**N=1134 (32%)**	**N=123 (28%)**			**N=88 (30%)**		
		OR	95% CI	p	OR	95% CI	p
Unadjusted		0.82	0.66-1.03	0.09	0.90	0.69-1.15	0.40
Model 1*		0.79	0.63-0.99	0.04	0.89	0.66-1.16	0.40
Model 2*		0.87	0.68-1.11	0.26	1.09	0.83-1.44	0.54
Model 3 *		0.87	0.67-1.11	0.27	1.13	0.84-1.53	0.41
Survival	**N=469 (13%)**	**N=58 (13%)**			**N=38 (13%)**		
		OR	95% CI	p	OR	95% CI	p
Unadjusted		0.99	0.74-1.32	0.95	0.96	0.67-1.36	0.81
Model 1*		0.87	0.65-1.18	0.37	0.94	0.66-1.34	0.73
Model 2*		1.02	0.74-1.41	0.89	1.19	0.81-1.75	0.37
Model 3 *		1.10	0.79-1.54	0.56	1.33	0.86-2.05	0.20

*Model 1: adjusted for age and gender.
*Model 2: adjusted for age, gender and presenting rhythm.
*Model 3: adjusted for age, gender, presenting rhythm, and covariates: location of arrest, witnessed arrest, bystander CPR, EMS response time, and comorbidities (MI, CHF, CVA, Afib, renal failure, lung disease).

SUPPLEMENTARY TABLE 2: Predictors of Presenting Rhythm (ventricular fibrillation as reference) from a single multinomial logistic regression model, limited to Hospitalized Patients (N=2720).

	Ventricular Fibrillation n=1531		Pulseless electrical activity N=448					Asystole N=741				
	n	%/m	n	%	OR*	95%CI	p	n	%/m	OR*	95%CI	p
Demographic Characteristics												
Age (year) mean(SD)	1494	67 (13)	412	72 (12)	1.03	1.02-1.04	<0.0001	705	70 (13)	1.01	0.99-1.01	0.16
Gender (M)	1531	77	448	65	0.81	0.63-1.05	0.12	741	63	0.74	0.58-0.93	0.01
Race (Ref: EA)	1327	87	355	79				582	78			
African Am.	124	8	64	14	1.99	1.37-2.92	<0.0001	95	13	1.29	0.88-1.88	0.19
Asian	80	5	29	7	1.31	0.80-2.15	0.28	64	9	1.27	0.82-1.98	0.27
SCA characteristics												
Location (Ref:Public)	525	35	50	11				59	8			
Residence	908	60	324	73	2.54	1.81-3.56	<0.0001	616	84	4.11	2.98-5.68	<0.0001
NH	48	3	56	13	9.66	5.48-17.1	<0.0001	55	8	4.61	2.59-8.23	<0.0001
Clinic	34	2	12	3	3.47	1.55-7.76	0.002	3	<1	0.72	0.18-2.88	0.64
Witnessed (Y)	1135	74	289	65	0.80	0.62-1.04	0.09	185	25	0.14	0.11-0.17	<0.0001
Bystander CPR (Y)	837	55	185	41	0.56	0.44-0.71	<0.0001	323	44	0.77	0.62-0.96	0.02
Response Time (min) mean(SD)	1520	5 (2)	444	5 (2)	1.09	1.02-1.16	0.006	736	5 (2)	1.07	1.01-1.13	0.02
Prior Inpatient diagnoses												
Myocardial Infarction	345	23	101	23	1.15	0.78-1.69	0.48	165	22	1.05	0.75-1.47	0.79
Congestive Heart Failure	475	32	169	38	0.86	0.64-1.15	0.30	280	38	0.96	0.74-1.26	0.79
Stroke	185	12	61	14	0.64	0.44-0.94	0.02	108	15	0.82	0.60-1.12	0.22
Atrial fibrillation	335	22	104	23	0.81	0.59-1.12	0.20	163	22	0.70	0.52-0.93	0.01
Renal Failure	78	5	45	10	1.39	0.88-2.21	0.16	87	12	1.64	1.09-2.46	0.02
Lung Disease	228	15	110	25	1.59	1.17-2.15	0.003	178	24	1.49	1.14-1.97	0.004
Hypertension	465	30	203	45	1.56	1.19-2.05	0.001	324	44	1.58	1.24-2.02	<0.0001
Diabetes	273	18	121	27	1.44	1.08-1.94	0.01	217	29	1.60	1.21-2.11	0.001
Coronary artery disease	627	41	174	39	0.64	0.45-0.90	0.01	309	41	0.70	0.52-0.94	0.02

Data presented as % except for continuous variables, which are presented as mean (SD)
*OR: The ratio of two odds ratios. The point estimate, 95% CI and p value are obtained with a multinomial logistic regression model with above covariates.

SUPPLEMENTARY TABLE 3 : Predictors of Ventricular Fibrillation as Presenting Rhythm Relative to Non-shockable Rhythms (PEA and asystole) in a Logistic Regression Model in all Ethnicities

	Non-Shockable rhythms (PEA & Asystole) N=2069		VF n= 2219				
	n	%/m	n	%/m	OR	95% CI	p
Demographic Characteristics							
Age (per year)	1956	70 (13)	2168	66 (14)	0.98	0.98-0.99	<0.0001
Gender (M)	2069	65	2219	79	1.53	1.30-1.80	<0.0001
Race (Ref: EA)	1656	80	1895	85			
African Am.	237	11	203	9	0.78	0.62-0.99	0.05
Asian	176	9	121	6	0.65	0.49-0.87	0.004
SCA characteristics							
Location (Ref:Public)	255	13	799	37			
Residence	1602	79	1292	59	0.34	0.29-0.42	<0.0001
NH	141	7	53	2	017	0.11-0.28	<0.0001
Clinic	22	1	39	2	0.45	0.24-0.86	0.01
Witnessed (Y)	787	38	1624	73	4.21	3.64-4.85	<0.0001
Bystander CPR (Y)	924	45	1204	54	1.32	1.14-1.53	<0.0001
Response Time (min)	2051	5 (2)	2202	5 (2)	0.94	0.91-0.98	0.002
Prior Inpatient medical problems							
MI	266	13	345	16	1.23	0.98-1.54	0.07
CHF	449	22	475	21	1.19	0.97-1.48	0.09
CVA	169	8	185	8	1.34	1.02-1.74	0.03
Atrial fibrillation	267	13	335	15	1.52	1.19-1.94	0.001
Renal Failure	132	6	78	4	0.59	0.41-0.84	0.003
Lung Disease	288	14	228	10	0.72	0.57-0.90	0.005

*Point estimate, confidence intervals and p value are obtained by a Logistic regression model with all above covariates.

SUPPLEMENTARY TABLE 4 : Predictors of Ventricular Fibrillation as presenting rhythm relative to non-shockable rhythms (PEA and asystole) in a logistic regression model in all Ethnicities limited to Hospitalized Cases n=2720

	Non-Shockable rhythms (PEA & Asystole) N=1189		**VF N= 1531**				
	n	**%/m**	**n**	**%/m**	OR	95% CI	p
Demographic Characteristics							
Age (per year)	1117	71 (13)	1494	67 (13)	0.98	0.98-0.99	<0.0001
Gender (M)	1189	64	1531	77	1.32	1.07-1.61	0.008
Race (Ref: EA)	937	79	1327	87			
African Am.	159	13	124	8	0.65	0.47-0.90	0.009
Asian	93	8	80	5	0.78	0.53-1.14	0.19
SCA characteristics							
Location (Ref:Public)	109	9	525	35			
Residence	940	80	908	60	0.30	0.23-0.38	<0.0001
NH	111	9	48	3	0.15	0.09-0.25	<0.0001
Clinic	15	1	34	2	0.48	0.22-1.04	0.06
Witnessed (Y)	474	40	1135	74	3.76	3.12-4.52	<0.0001
Bystander CPR (Y)	508	43	837	55	1.48	1.23-1.78	<0.0001
Response Time (min)	1180	5 (2)	1520	5 (2)	0.93	0.89-0.97	0.002
Prior Inpatient medical problems							
MI	266	22	345	23	0.91	0.68-1.22	0.53
CHF	449	38	475	32	1.09	0.87-1.36	0.47
CVA	169	14	185	12	1.34	1.02-1.77	0.04
Atrial fibrillation	267	22	335	22	1.36	1.06-1.74	0.02
Renal Failure	132	11	78	5	0.66	0.45-0.94	0.02
Lung Disease	288	24	228	15	0.66	0.52-0.84	0.001
HTN	527	44	465	30	0.63	0.52-0.78	<0.0001
DM	338	28	273	18	0.65	0.52-0.82	<0.0001
CAD	483	41	627	41	1.49	1.15-1.94	0.003

*Point estimate, confidence intervals and p value are obtained by a Logistic regression model with all above covariates.

SUPPLEMENTARY FIGURE 1: Flow Chart