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Original Article

Racial Disparities in Management and Outcomes of Out-of-Hospital Cardiac Arrest Complicating Myocardial Infarction: A National Study From England and Wales

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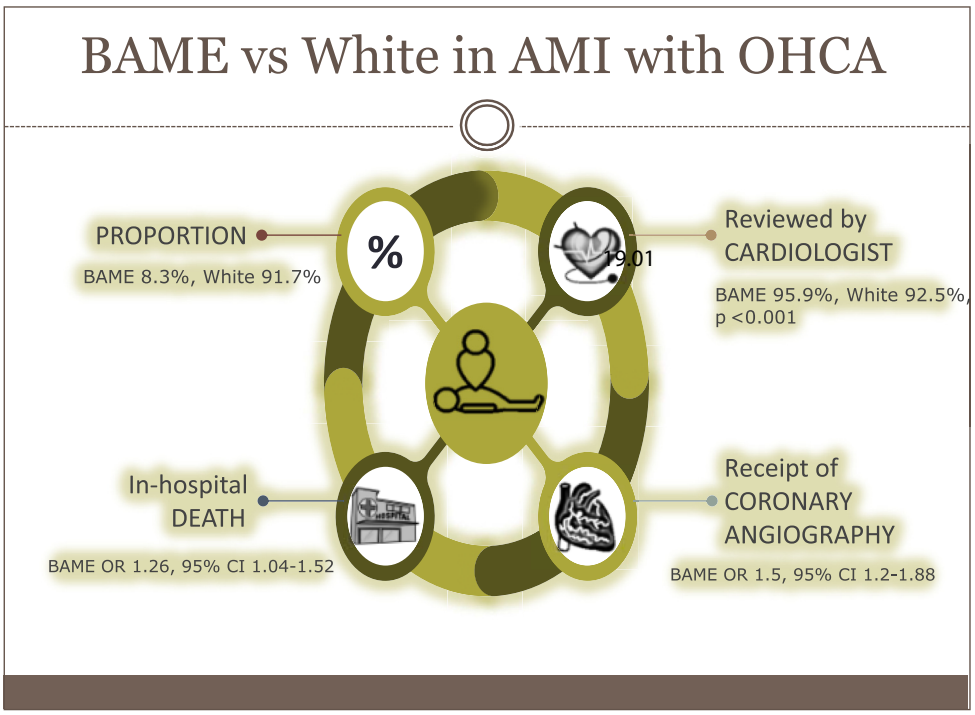

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ABSTRACT

Background: Studies of racial disparities in care of patients admitted with an out-of-hospital cardiac arrest (OHCA) in the setting of acute myocardial infarction (AMI) have shown inconsistent results. Whether these differences in care exist in the universal healthcare system in United Kingdom is unknown.

Methods: Patients admitted with a diagnosis of AMI and OHCA between 2010 and 2017 from the Myocardial Ischaemia National Audit Project (MINAP) were studied. All patients were stratified based on ethnicity into a Black, Asian, or minority ethnicity (BAME) group vs a White group. We used multivariable logistic regression models to evaluate the predictors of clinical outcomes and treatment strategy.

Results: From 14,287 patients admitted with AMI complicated by OHCA, BAME patients constituted a minority of patients (1185 [8.3%]), compared with a White group (13,102 [91.7%]). BAME patients were younger (median age [interquartile range]) for BAME group, 58 [50-70] years; for White group, 65 [55-74] years). Cardiogenic shock (BAME group, 33%; White group, 20.7%; $P < 0.001$) and severe left ventricular impairment (BAME group, 21%; White group, 16.5%; $P < 0.003$) were more frequent among BAME patients. BAME patients were more likely to be seen by a cardiologist (BAME group, 95.9%; White group, 92.5%; $P < 0.001$) and were more likely to receive coronary angiography than the White group (odds ratio [OR] 1.5, 95% confidence interval [CI] 1.2-1.88). The BAME group had significantly higher in-hospital mortality (OR 1.26, 95% CI 1.04-1.52) and re-infarction (OR 1.52, 95% CI 1.06-2.18) than the White group.

Conclusions: BAME patients were more likely to be seen by a cardiologist and receive coronary angiography than White patients. Despite this difference, the in-hospital mortality of BAME patients, particularly in the Asian population, was significantly higher.

RÉSUMÉ

Introduction : Les études sur les inégalités raciales en matière de soins aux patients admis en raison d'un arrêt cardiaque hors de l'hôpital (ACHO) dans le cadre d'un infarctus aigu du myocarde (IAM) ont montré des résultats contradictoires. On ignore si ces différences en matière de soins existent dans le système de soins de santé universel de l'Angleterre.

Méthodes : Les patients admis en raison d'un diagnostic d'IAM et d'ACHO entre 2010 et 2017 du Myocardial Ischaemia National Audit Project (MINAP) ont fait l'objet de l'étude. Nous avons réparti tous les patients selon l'origine ethnique dans le groupe BAME (de l'anglais Black, Asian and minority ethnic, c.-à-d. Noirs, Asiatiques ou d'une minorité ethnique) *vs* le groupe des Blancs. Nous avons utilisé les modèles multivariés de régression logistique pour évaluer les prédicteurs des résultats cliniques et la stratégie de traitement.

Résultats : Parmi les 14 287 patients admis en raison d'un IAM compliqué par l'ACHO, les patients du BAME constituaient une minorité de patients (1 185 [8,3 %]) par rapport au groupe des Blancs (13 102 [91,7 %]). Les patients du groupe BAME étaient plus jeunes (âge médian [écart interquartile]), 58 [50-70] ans que le groupe des Blancs, 65 [55-74] ans). Le choc cardiogénique (groupe BAME, 33 %; groupe des Blancs, 20,7 %; $P < 0,001$) et l'insuffisance ventriculaire gauche grave (groupe BAME, 21 %; groupe des Blancs, 16,5 %; $P < 0,003$) étaient plus fréquents au sein des patients du BAME. Il était plus probable que les patients du BAME soient vus par un cardiologue (groupe du BAME, 95,9 %; groupe des Blancs, 92,5 %; $P < 0,001$) et qu'ils passent une angiographie coronarienne que le groupe des Blancs (ratio d'incidence approché [RIA] 1,5, intervalle de confiance [IC] à 95 % 1,2-1,88). Le groupe BAME avait une mortalité intrahospitalière (RIA 1,26, IC à 95 % 1,04-1,52) et une récidive d'infarctus (RIA 1,52, IC à 95 % 1,06-2,18) plus élevées que le groupe des Blancs.

Conclusions : Il était plus probable que les patients du BAME soient vus par un cardiologue et qu'ils passent une angiographie coronarienne que les patients blancs. Malgré cette différence, la mortalité intrahospitalière des patients du BAME, particulièrement de la population asiatique, était significativement plus élevée.

Out-of-hospital cardiac arrest (OHCA) is a major cause of cardiovascular mortality.[1,2] Approximately 275,000 persons experience OHCA in Europe annually, with only 29,000 surviving to hospital discharge.[3] Ethnicity is an important factor in determining an individual's place of residence, socioeconomic status, and access to cardiopulmonary resuscitation in their community, factors known to be associated with significant variation in the response to and outcomes of OHCA.[4,5]

Although many studies have assessed racial differences in the care of OHCA complicated by an acute myocardial infarction (AMI), results have been inconsistent.[6-9] Some studies suggest that clinical outcomes are worse among ethnic minorities, compared with the White population.[6,7,10] These studies attribute these racial disparities to various factors that affect community response, such as socioeconomic status, lack of awareness in recognizing symptoms, delay in seeking early medical help, and implicit bias from the treating physicians.[4,5] For instance, a meta-analysis of racial disparities in outcomes of OHCA complicating AMI in the US showed that Black populations have worse outcomes than White populations.[6] Most studies of racial disparities in AMI with OHCA have used data from the US; studies examining OHCA characteristics and survival in Europe and the United Kingdom[6] are lacking. Data from the United Kingdom can give additional insights on the impact of racial disparities, because of differences in its population structure, compared with that in the US, and the availability of universal healthcare through the National Health Service (NHS). The NHS is a universal

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Ethics Statement: Ethical approval was not required for this study, under current arrangements by the National Health Service research governance body, because the MINAP database was collected and used for research purposes without informed patient consent by the National Institute for Cardiovascular Outcomes Research, under section 251 of the National Health Service Act of 2006.

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public sector system that provides universal access to health services to the whole population, independent of their socioeconomic status. In contrast, access to US healthcare systems and the quality of care received depend, to a greater extent, on patients' socioeconomic status and medical insurance coverage. This means that individuals in the lower socioeconomic strata of society are unable to afford healthcare expenses, despite large governmental expenditure, placing the Black population at a disproportional disadvantage.[11,12]

We used the Myocardial Ischaemia National Audit Project (MINAP), a national registry of AMI hospitalizations in England and Wales, to study the impact of patients' ethnicity on the processes of care and the clinical outcomes of patients admitted with AMI complicated by OHCA between 2010 and 2017.

Methods

Study design

The MINAP is a national cardiac audit that collects information relating to the presenting profile and clinical care of patients hospitalized with a diagnosis of AMI in England.[13-15] The data collected are utilized for auditing quality of care and public reporting of AMI patients and also provide a resource for academic research.[12,14,16] The database contains information about patient demographics, admission time and method, cardiovascular comorbidities, clinical characteristics, relevant investigations, in-hospital pharmacologic and interventional treatments, in-hospital outcomes, and discharge treatments.[15,17]

Study population

The cohort for this study included all patients aged $>$ 18 years admitted with a final diagnosis of AMI (either ST-segment elevation myocardial infarction [STEMI] or non-STEMI [NSTEMI]) and OHCA between January 1, 2010 and March 31, 2017. The discharge diagnosis of AMI was established by the treating clinician according to the presenting history, clinical examination, and results of inpatient investigations based on the consensus document of the Joint European Society of Cardiology and the American College of Cardiology.[18] The total number of patients diagnosed with AMI was 664,740. Of those, the number of patients who did not present with OHCA was 511,329. Patients with missing data, including ST elevation on presentation (41,124 patients), ethnicity (55,153 patients), cardiac arrest site (22,140 patients), and in-hospital mortality information (20,707 patients) were excluded from the analysis. The final number of patients included in the cohort was 14,287 (Supplemental Fig. S1).

In the MINAP, a patient's ethnic group was defined based on patient self- reporting using race categories that are used nationally in this and other national electronic health records. All patients were stratified into 1 of 2 ethnicity groups: a Black, Asian, or minority ethnicity (BAME) group vs a White group. The BAME group included those whose race was recorded as Black (including Caribbean, African, Black British, and any other Black background), Asian (including Indian, Pakistani, Bangladeshi, Asian British, and any other Asian Background, but excluding Chinese), or other non-White ethnicity (including Chinese). We collected detailed information on patient characteristics, clinical presentations, comorbidities, and discharge pharmacology. The outcomes of interest were in-hospital mortality, re-infarction, major bleeding, and utilization of coronary angiography and percutaneous coronary intervention (PCI). In-hospital major bleeding was defined as a composite of intracranial bleeding, retroperitoneal bleeding, and any bleeding with a $>$ 3 g/L fall in hemoglobin concentration.

Ethical approval

Ethical approval was not required for this study, under current arrangements by the NHS research governance body, because the MINAP database was collected and used for research purposes without informed patient consent by the National Institute for Cardiovascular Outcomes Research under section 251 of the National Health Service Act of 2006.[19]

Data quality

The MINAP tackles oversight by providing guidance and technical advice for staff who are entering data, via a dedicated helpdesk, and consistently using error-checking routines in a MINAP data application. The completeness of 20 key fields is closely monitored and is generally above 95%. These fields include NHS number, discharge diagnosis, hospital mortality, and secondary prevention medication prescribed at discharge. A data validation exercise is done annually and requires every hospital to re-enter 20 data items from the medical records of 20 randomly selected patients, using a specially designed data validation tool.[16]

Statistical analysis

We described the baseline characteristics as number and percentage for categorical variables, and as median and interquartile range for continuous variables. The χ^2 test and *t*-test were used to test for statistical significance between categorical and continuous variables, respectively. The Kruskal—Wallis test was used for skewed data. We used multiple imputation techniques with chained equations to account for the missing data. Age, sex, ethnicity, clinical diagnosis, and in-hospital mortality were registered as regular variables in the imputations model, and all other variables, including body mass index, seen by cardiologists, left ventricular systolic function, previous PCI, coronary artery bypass graft, heart failure, hypercholesterolemia, angina, cerebrovascular disease, peripheral vascular disease, creatinine levels, diabetes, hypertension, smoking status, asthma or chronic obstructive pulmonary disease, family history of coronary disease, in-hospital use of low-molecular-weight heparin, warfarin, loop diuretics, oral beta-blockers, and angiotensin-converting enzyme inhibitor were imputed (Supplemental Table S1). The variable selection in the model was based on previous studies using the MINAP registry, and prior clinical knowledge.[14] Using these models, 10 imputed datasets were generated that were used to perform all the analyses. Multivariable logistic regression models were used to study the association between ethnicity and clinical outcomes. We undertook a sensitivity analysis to compare and contrast clinical characteristics, management strategies, and clinical outcomes among the Black population, the Asian population, and other non-White ethnic minorities (Other), using the White group as a reference. All models included the same variables used in the multiple imputation

models, as well as the year of admission. Estimates in the form of odds ratios (ORs) and 95% confidence intervals (95% CIs) were reported. Statistical significance was considered to be indicated by an alpha of 0.05 in all the 2-sided tests used. Stata, version 14.1 (StataCorp LLC, College Station, TX), was used to perform all the analyses.

Results

Patients' characteristics

Of 14,287 patients admitted with AMI complicated by OHCA, the BAME patients constituted a minority (8.3%). The BAME patients were younger (BAME group median age [interquartile range] 58 [50-70] years; White group median age [interquartile range] 65 [55-74] years), with a lower proportion of women (BAME group, 18.0%; White group, 23.2%; $P < 0.001$). Cardiogenic shock (BAME group, 33%; White group, 20.7%; $P < 0.001$) and severe left ventricular impairment (BAME group, 21%; White group, 16.5%; $P < 0.003$) were more frequent among BAME patients. Cardiometabolic risk factors were more prevalent in BAME patients than White patients, particularly diabetes (BAME group, 31%; White group, 13%; $P < 0.001$), hypertension (BAME group, 48%; White group, 41%; $P < 0.001$), hypercholesterolemia (BAME group, 35%; White group, 26%; $P < 0.001$), heart failure (BAME group, 6.5%; White group, 4.6%; $P = 0.008$), and chronic kidney disease (BAME group, 5.2%; White group, 3.8%; $P = 0.024$). Table 1 shows the patients' characteristics and the clinical presentation of AMI patients with OHCA. The proportion of AMI patients with OHCA from the BAME group tripled, from around 4% in 2010 to 12% in 2017 (Fig. 1).

Table 1. Characteristics and clinical presentation of acute myocardial infarction (MI) patients with out-of-hospital cardiac arrest

Characteristic	White	BAME	*P*
n	13,102	1185	
Age, y	65.0 (55.0, 74.0)	58.0 (50.0, 70.0)	< 0.001
Women	3045 (23.2)	213 (18.0)	< 0.001
BMI	26.9 (24.0, 30.2)	26.3 (23.2, 29.5)	0.35
Clinical diagnosis			
STEMI	10027 (76.5)	973 (82.1)	< 0.001
NSTEMI/UA	3075 (23.5)	212 (17.9)	
Site of infarction			
Anterior	4298 (48.2)	493 (55.5)	< 0.001
Inferior	3074 (34.4)	246 (27.7)	
Posterior	492 (5.5)	38 (4.3)	
Lateral	450 (5.0)	48 (5.4)	
Undetermined	610 (6.8)	63 (7.1)	
Killip class			
I	5357 (62.4)	434 (49.9)	< 0.001
II	1020 (11.9)	97 (11.2)	
III	427 (5.0)	44 (5.1)	
IV (shock)	1781 (20.7)	294 (33.8)	
LV function			
Good*	2720 (26.2)	248 (25.7)	0.003
Moderate	3315 (31.9)	296 (30.7)	
Poor	1716 (16.5)	203 (21.1)	
Creatinine, mmol/L	94.0 (78.0, 116.0)	97.0 (81.0, 126.0)	0.11
Elevated cardiac enzymes	11176 (97.1)	939 (93.2)	< 0.001
Angina pectoris	1636 (14.4)	162 (15.4)	0.41
Previous MI	1982 (17.3)	199 (18.8)	0.22
Diabetes	1614 (13.4)	334 (30.8)	< 0.001
Hypertension	4649 (40.6)	511 (48.2)	< 0.001
Hypercholesterolemia	2934 (26.1)	365 (35.1)	< 0.001
Smoking			
Never	3989 (37.4)	527 (53.6)	< 0.001
Ex-smoker	2613 (24.5)	145 (14.7)	
Smoker	4056 (38.1)	312 (31.7)	
FH of coronary artery disease	2226 (23.8)	167 (18.4)	< 0.001
Previous PCI	883 (7.7)	134 (12.7)	< 0.001
Previous CABG	581 (5.1)	50 (4.7)	0.64
Stroke	713 (6.3)	75 (7.1)	0.28
Peripheral vascular disease	453 (4.0)	20 (1.9)	< 0.001
Heart failure	525 (4.6)	68 (6.5)	0.008
Chronic kidney disease	429 (3.8)	54 (5.2)	0.024
Asthma/COPD	1378 (12.1)	94 (8.9)	0.002

BAME, Black, Asian, or minority ethnicity; BMI, body mass index; CABG, coronary artery bypass graft; COPD, chronic obstructive pulmonary disease; FH, family history; LV, left ventricle; NSTEMI, non-STEMI; PCI, percutaneous coronary intervention; STEMI, ST elevation myocardial infarction; UA, unstable angina.

*LV function assessment is based on ejection fraction measurement from transthoracic echocardiogram.

Processes of care

The BAME patients were more likely to be seen by a cardiologist (BAME group, 95.9%; White group, 92.5%; $P < 0.001$), receive coronary angiography (BAME group, 88%; White group, 79.6%; $P < 0.001$), and receive PCI (BAME group, 45%; White group, 39.5%; $P < 0.001$). Administration of dual antiplatelet therapy (BAME group, 75.6%; White group, 77.6%; $P = 0.12$) and most of the other evidence-based medications, such as beta blockers (BAME group, 70.2%; White group 70.1%; $P = 0.93$) and fondaparinux (BAME group, 11.9%; White group, 14.1%; $P = 0.054$) in the BAME group was relatively similar that in the White group, as illustrated by Table 2. However, angiotensin-converting enzyme inhibitors (BAME group, 59.9%; White group, 54.7%; $P = 0.002$) were more commonly administered in the BAME group, whereas statins (BAME group, 55%; White group, 58.2%; $P = 0.034$) were more commonly administered in the White group. After adjusting for baseline risk-factor differences, those in the BAME group were more likely to receive coronary angiography than those in the White group (OR 1.5, 95% CI 1.2-1.88) (Supplemental Table S2).

Clinical outcomes

The BAME group had a higher crude in-hospital mortality (BAME group, 31.2%; White group, 26.6%; $P < 0.001$) and re-infarction (BAME group, 3.6%; White group, 2.3%; $P = 0.008$) rates than the White group. The bleeding rate was not significantly different between the 2 groups (BAME group, 2.8%; White group, 3.1%; $P = 0.63$). The crude in-hospital mortality rate in the White group has not changed over the past decade; in contrast, in-hospital mortality in BAME patients doubled, from around 16% in 2010 to around 30% in 2017 (Fig. 2).

After adjusting for the comorbidities and in-hospital management, the BAME group had significantly higher in-hospital mortality (OR 1.26, 95% CI 1.04-1.52) and re-infarction (OR 1.52, 95% CI 1.06-2.18) rates than the White group, as shown in Table 3.

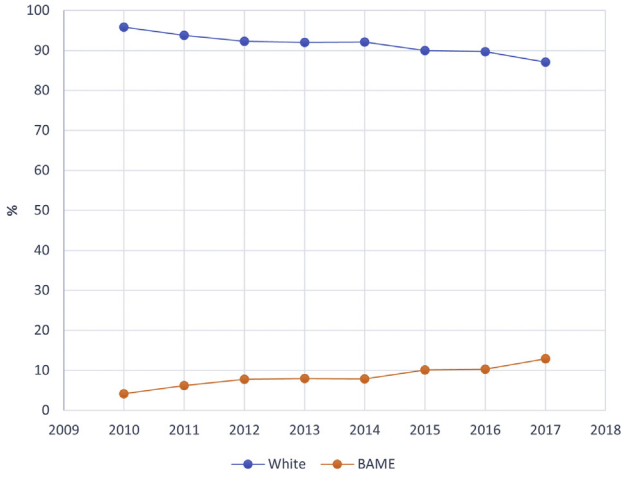

Figure 1. Proportion of patients with acute myocardial infarction with out-of hospital cardiac arrest from the Black, Asian, or minority ethnicity (BAME) group.

Sensitivity analysis

We did a sensitivity analysis to compare the clinical characteristics, management strategies, and clinical outcomes among the Black population, the Asian population, and other non-White ethnic minorities (Other), using the White group as a reference. Clinical characteristics for each ethnic group are presented in Supplemental Table S3; pharmacotherapy, management strategies, and crude in-hospital clinical outcomes are presented in Supplemental Table S4. After adjustment, the Black population rates of in-hospital death (OR 0.88, 95% CI 0.52-1.5) and receipt of coronary angiography (OR 1.5, 95% CI 0.84-2.77) were similar to those in the White population. In contrast, the in-hospital death rate was higher in the Asian population (OR 1.4, 95% CI 1.1-1.78). Table 4 shows the clinical outcomes of the individual racial groups that make up the BAME group. Figure 3 shows the independent predictors of in-hospital mortality of white and BAME patients.

Table 2. Processes of care and unadjusted clinical outcomes of patients with acute myocardial infarction with out-of-hospital cardiac arrest

Level	White	BAME	
n	13,102	1185	*P*
Seen by cardiologist	11,950 (92.5)	1123 (95.9)	< 0.001
LMWH	5379 (50.0)	430 (43.9)	< 0.001
Unfractionated heparin	4497 (42.1)	378 (38.7)	0.044
Fondaparinux	1507 (14.1)	115 (11.9)	0.054
Aspirin	11,674 (93.4)	1075 (94.8)	0.069
GP IIIa/IIb inhibitors	1716 (15.7)	161 (16.3)	0.64
P2Y12 inhibitors	10,064 (81.8)	881 (80.3)	0.21
DAPT	9700 (77.6)	857 (75.6)	0.12
Furosemide	3066 (28.8)	272 (28.4)	0.78
Oral beta-blockers	7471 (70.1)	682 (70.2)	0.93
Discharged on beta-blockers	7201 (56.8)	629 (53.9)	0.053
ACEI	5915 (54.7)	584 (59.9)	0.002
Statins	7371 (58.2)	643 (55.0)	0.034
Coronary angiography	10,031 (79.6)	1013 (88.2)	< 0.001
PCI	3707 (39.5)	412 (45.4)	< 0.001
CABG	368 (3.9)	34 (3.7)	0.80
In-hospital death	3491 (26.6)	370 (31.2)	< 0.001
Re-infarction	286 (2.3)	40 (3.6)	0.008
Bleeding	397 (3.1)	33 (2.8)	0.63

Values are n (%), unless otherwise indicated.

ACEI, angiotensin-conversting enzyme inhibitor; BAME, Black, Asian, or minority ethnicity; CABG, coronary artery bypass graft; DAPT, dual antiplatelet therapy; GP, glycoprotein; LMWH, low-molecular-weight heparin; LV, left ventricle; MI, myocardial infarction; NSTEMI, non-STEMI; PCI, percutaneous coronary intervention; STEMI, ST elevation myocardial infarction.

Discussion

In this national cohort of AMI patients presenting with OHCA, the BAME patients were younger, had a relatively higher-risk comorbidity profile, and were sicker at the time of presentation, with a greater frequency of STEMI, cardiogenic shock, and severe left ventricular impairment, compared with the White population. BAME patients also had a relatively higher frequency of cardiovascular comorbidities such as diabetes, hypertension, and history of previous PCI. Administration of evidence-based medications and processes of care in BAME patients was often better, with BAME patients more likely to be seen by a cardiologist and to receive coronary angiography than the White population. Despite this, the in-hospital mortality rate of BAME patients was significantly higher than that of their White counterparts, with the worst outcomes seen in the Asian population.

Notably, BAME patients often had better administration of evidence-based medications and process of care, compared with the White population. The BAME population was much younger than the White population, sicker at the time of presentation, and had a higher prevalence of cardiovascular risk factors. These differences might have encouraged physicians to adopt a more invasive approach for management of the BAME patients. Furthermore, BAME patients were more likely to present with STEMI, which may also contribute to higher rates of coronary angiography use in this patient population. The MINAP registry does not capture data relating to optimization to target, which is an important component of quality of care, and so cannot inform as to whether there are significant differences in this factor in the patient groups studied.

Previous studies on the link between ethnicity and in-hospital management of OHCA revealed that ethnic minorities had a lower rate of inpatient cardiac procedures compared to Whites. For instance, a registry study from the Los Angeles County Emergency Medical Services system in 2019 revealed that minority groups, particularly the Black and Asian populations, had a lower frequency of in-hospital interventions, such as coronary angiography and PCI.[20] Groeneveld et al. examined the rates of cardiac procedure utilization and long-term survival after cardiac arrest. Their study showed that the Black population was less likely to undergo potentially life-saving procedures.[21] In the current analysis of a national cohort of patients with AMI with OHCA from England and Wales, we report that BAME patients had better access to some aspects of inpatient management, such as receiving cardiologist input and use of coronary angiography and PCI. These findings suggest that, in contrast to findings in studies performed in the US, there are no significant racial disparities in the in-hospital management of AMI patients presenting with OHCA, and that the differences in the in-hospital processes of care might

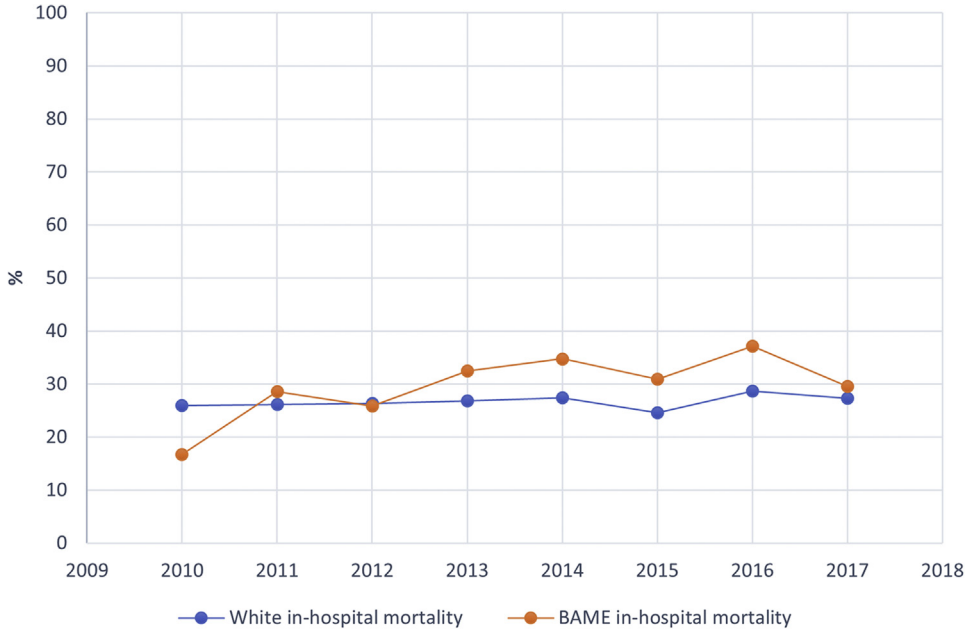

Figure 2. Crude in-hospital mortality rate of patients with acute myocardial infarction with out-of hospital cardiac arrest from the Black, Asian, or minority ethnicity (BAME) group.

not contribute to the lower survival rate reported in BAME patients in the United Kingdom.

The low survival rates in BAME patients reported in the earlier studies from the US were attributed to different factors related to the community response, such as delayed identification of OHCA, longer response time, lack of awareness about OHCA management, and socioeconomic factors along with other social determinants of health.[22-24] To the best of our knowledge, this is the first national study from Europe to address the racial disparities in management and outcomes of AMI complicated by OHCA. Our study shows that the crude mortality rate in the BAME population doubled over the study period, in contrast to that in the White population, for whom the in-hospital mortality rate remained relatively stable. Despite being younger and having similar in-hospital care, compared with the White population, BAME patients had higher odds of in-hospital death.

Survival following OHCA depends to a great extent on a "chain of survival" that begins with early recognition of OHCA and activation of the emergency response system, cardiopulmonary resuscitation (CPR), defibrillation, advanced life support, and integrated care after OHCA.[25] The efficiency of this chain of survival is linked to socioeconomic status and neighbourhood characteristics.[4,5] For example, Sasson et al. analyzed a large cohort from the Cardiac Arrest Registry to Enhance Survival (CARES) registry in the US and found that patients who had an OHCA in low-income Black neighbourhoods were less likely to receive bystander-initiated CPR than those in high-income White neighbourhoods.[4] A recent study revealed that patients with low socioeconomic status also receive delayed CPR.[5] Socioeconomic status and level of education were also linked to CPR training disparities, with the White population being trained in CPR more frequently than BAME minorities.[26,27] As BAME patients tend to have lower socioeconomic status and live in lower-income neighbourhoods, compared with the White population, in the United Kingdom,[28] they have a higher risk of delayed OHCA identification, a less-efficient chain of survival, and subsequently worse clinical outcomes. Moreover, neighbourhoods with a higher incidence of OHCA and low incidence of bystander CPR had a greater proportion of their populations from ethnic minority groups and people not born in the United Kingdom.[29] The outcomes of the BAME group can be improved by providing training on CPR and defibrillators to the BAME community members, ensuring adequate availability of defibrillators in the neighbourhoods, and

Table 3. Adjusted clinical outcomes of patients with acute myocardial infarction with out-of-hospital cardiac arrest, and ethnicity odds ratio (OR)

Outcome	BAME OR (95% CI)
In-hospital death	1.26 (1.04−1.52)
Re-infarction	1.52 (1.06−2.18)
Bleeding	0.88 (0.61−1.29)

Reference is White patients.
BAME, Black, Asian, or minority ethnicity; CI, confidence interval.

Table 4. Sensitivity analysis of clinical outcomes of patients with acute myocardial infarction with out-of-hospital cardiac arrest, and ethnicity odds ratio (OR)

Outcome	Black	Asian	Other ethnicities
In-hospital death	0.88 (0.52−1.51)	1.4 (1.10−1.78)	1.17 (0.85−1.62)
Re-infarction	2.1 (0.89−1.5)	1.79 (1.17−2.73)	0.8 (0.34−1.8)
Bleeding	0.7 (0.21−2.2)	1.05 (0.67−1.66)	0.67 (0.32−1.37)
Receipt of coronary angiography	1.53 (0.84−2.77)	1.38 (1.05−1.82)	1.81 (1.18−2.78)

Reference is White patients. Values are OR (95% confidence interval).

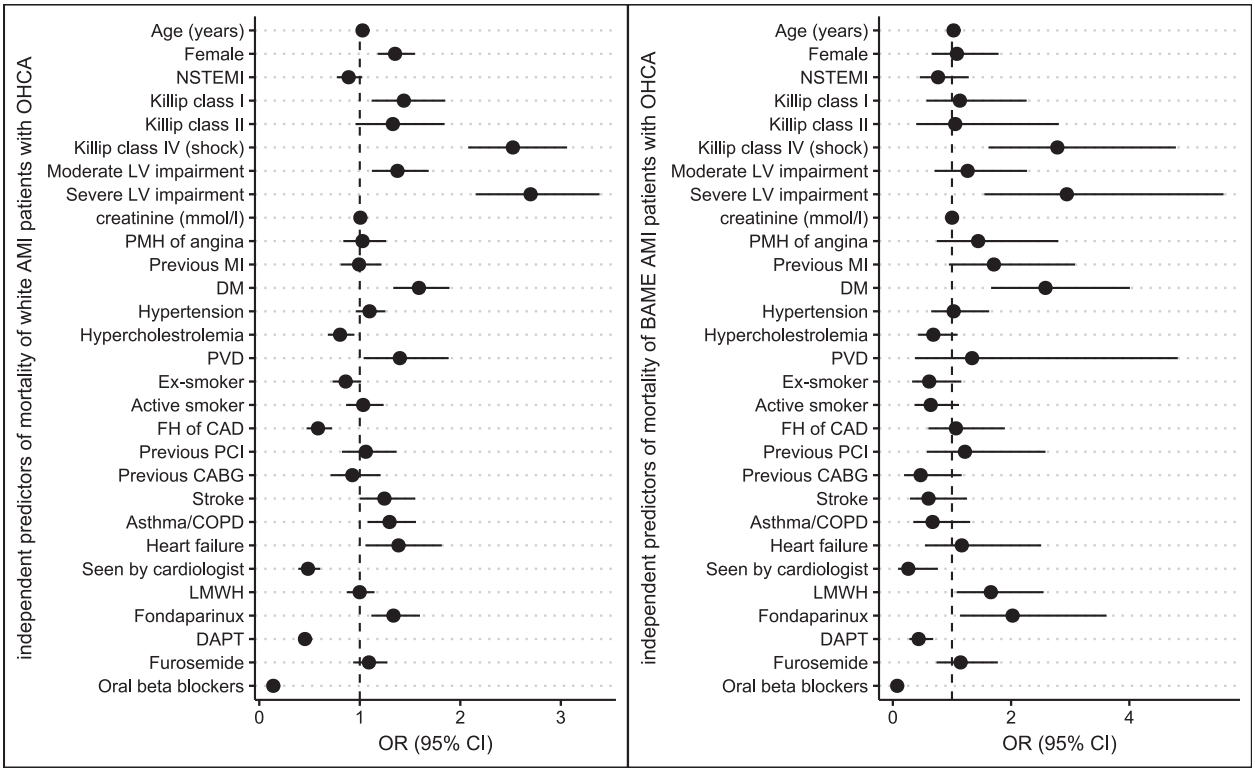

Figure 3. Independent predictors of in-hospital mortality of White and Black, Asian, or minority ethnicity (BAME) patients. CABG, coronary artery bypass graft; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disorder; DAPT, dual antiplatelet therapy; DM, diabetes mellitus; FH, family history; LV, left ventricular; LMWH, low-molecular-weight heparin; MI, myocardial infarction; NSTEMI; non-ST segment elevation myocardial infarction; PCI, percutaneous coronary intervention; PMH, past medical history; PVD, peripheral vascular disease.

engaging the community centres and leaders in improving community awareness about the importance of the prehospital management of OHCA.

Our subgroup analysis showed that the Black population had similar survival and revascularization rates, compared with the White population, but the Asian population had a higher risk of in-hospital death and higher rates of coronary angiography and revascularization than the White population. In contrast to our results, the Shah et al. study on the outcomes of OHCA in the South Asian population revealed that the quality of care and admission to survival rates were comparable to those in the White population.[30] The reasons behind the lower survival rates we reported for the Asian group cannot be fully explained by this study, especially with the small number of Black and Asian patients in the MINAP registry. Nonetheless, clinicians and policymakers may be interested in studying prehospital factors that may contribute to this lower rate, as a step toward reducing mortality in this group.

Strengths and limitations

One of the main strengths of this study is that we are able to study whether there are racial disparities in the management and outcomes for patients with AMI presenting with OHCA, from a national registry in which the data were collected prospectively over a long period of time. This study also has limitations that should be considered when interpreting the results. First, as the MINAP registry is an in-hospital AMI registry, it captures only patients with OHCA that complicates AMI, and patients who survived to hospital admission. It provides no insight into outcomes of other types of OHCA, for which there may also be racial disparities. Second, the MINAP database lacks information regarding long-term mortality and other outcomes, and does not capture the appropriateness of treatment decisions related to coronary angiography and inpatient management, nor adherence to and optimal titration of evidence-based medications. There are no data related to intensive-care management such as post-resuscitation cooling and ventilation. Finally, the MINAP registry does not provide any insight into the time to return of spontaneous circulation for those who experience OHCA in the community, or the management and quality of care prior to hospital admission. The MINAP registry does not capture whether differences in the processes of care between the 2 study groups is attributable to a higher prevalence of contraindications to coronary angiography in the White group. Although the MINAP registry provides insight about the neurologic deficit that occurs immediately after OHCA, it does not include information about long-term survival free from neurologic deficit.

Conclusions

BAME patients are increasingly presenting with AMI complicated by OHCA and have significantly higher in-hospital mortality compared to the White population, despite consistent inpatient management. The differences in the

community response and neighbourhood characteristics that interfere with the chain of survival in BAME patients should be studied and addressed in order to close the gap in the in-hospital survival between the BAME and White populations.

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Disclosures

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References

1. Forslund A-S, Söderberg S, Jansson J-H, Lundblad D. Trends in incidence and outcome of out-of-hospital cardiac arrest among people with validated myocardial infarction. Eur J Prev Cardiol 2013;20:260-7.
2. Nichol G, Thomas E, Callaway CW, et al. Regional variation in out-of-hospital cardiac arrest incidence and outcome. JAMA 2008;300:1423-31.
3. Atwood C, Eisenberg MS, Herlitz J, Rea TD. Incidence of EMS-treated out-of-hospital cardiac arrest in Europe. Resuscitation 2005;67:75-80.
4. Sasson C, Magid DJ, Chan P, et al. Association of neighborhood characteristics with bystander-initiated CPR. N Engl J Med 2012;367:1607-15.
5. Agerström J, Carlsson M, Bremer A, et al. Discriminatory cardiac arrest care? Patients with low socioeconomic status receive delayed cardiopulmonary resuscitation and are less likely to survive an in-hospital cardiac arrest. Eur Heart J 2021;42:861-9.
6. Shah KSV, Shah ASV, Bhopal R. Systematic review and meta-analysis of out-of-hospital cardiac arrest and race or ethnicity: black US populations fare worse. Eur J Prev Cardiol 2014;21:619-38.
7. Chen J, Rathore SS, Radford MJ, Wang Y, Krumholz HM. Racial differences in the use of cardiac catheterization after acute myocardial infarction. N Engl J Med 2001;344:1443-9.
8. Sayegh AJ, Swor R, Chu KH, et al. Does race or socioeconomic status predict adverse outcome after out of hospital cardiac arrest: a multi-center study. Resuscitation 1999;40:141-6.
9. Galea S, Blaney S, Nandi A, et al. Explaining racial disparities in incidence of and survival from out-of-hospital cardiac arrest. Am J Epidemiol 2007;166:534-43.
10. Cowie MR, Fahrenbruch CE, Cobb LA, Hallstrom AP. Out-of-hospital cardiac arrest: racial differences in outcome in Seattle. Am J Public Health 1993;83:955-9.
11. Kerr DJ, Scott M. British lessons on health care reform. N Engl J Med 2009;361:e21.
12. Moledina SM, Shoaib A, Weston C, et al. Ethnic disparities in care and outcomes of non-ST-segment elevation myocardial infarction: a nationwide cohort study. Eur Heart J Qual Care Clin Outcomes April 21, 2021 [online ahead of print]; https://doi.org/10.1093/ehjqcco/qcab030.
13. Birkhead JS, Weston CFM, Chen R. Determinants and outcomes of coronary angiography after non-ST-segment elevation myocardial infarction. A cohort study of the Myocardial Ischaemia National Audit Project (MINAP). Heart 2009;95:1593-9.
14. Rashid M, Curzen N, Kinnaird T, et al. Baseline risk, timing of invasive strategy and guideline compliance in NSTEMI: nationwide analysis from MINAP. Int J Cardiol 2020;301:7-13.
15. Rashid M, Kontopantelis E, Kinnaird T, et al. Association between hospital cardiac catheter laboratory status, use of an invasive strategy, and outcomes after NSTEMI. Can J Cardiol 2020;36:868-77.
16. Herrett E, Smeeth L, Walker L, Weston C; MINAP Academic Group. The Myocardial Ischaemia National Audit Project (MINAP). Heart 2010;96:1264-7.
17. Wu J, Mamas M, Rashid M, et al. Patient response, treatments, and mortality for acute myocardial infarction during the COVID-19 pandemic. Eur Heart J Qual Care Clin Outcomes 2021;7:238-46.
18. Alpert JS, Thygesen K, Antman E, Bassand JP. Myocardial infarction redefined—a consensus document of The Joint European Society of Cardiology/American College of Cardiology Committee for the redefinition of myocardial infarction. J Am Coll Cardiol 2000;36:959-69.
19. National Archives. National Health Service Act 2006. Available at: https://www.legislation.gov.uk/ukpga/2006/41/contents. Accessed October 21, 2020.
20. Bosson N, Fang A, Kaji AH, et al. Racial and ethnic differences in outcomes after out-of-hospital cardiac arrest: Hispanics and Blacks may fare worse than non-Hispanic Whites. Resuscitation 2019;137:29-34.
21. Groeneveld PW, Heidenreich PA, Garber AM. Racial disparity in cardiac procedures and mortality among long-term survivors of cardiac arrest. Circulation 2003;108:286-91.
22. Becker LB, Han BH, Meyer PM, et al. Racial differences in the incidence of cardiac arrest and subsequent survival. N Engl J Med 1993;329:600-6.
23. McNally B, Robb R, Mehta M, et al. Out-of-hospital cardiac arrest surveillance— Cardiac Arrest Registry to Enhance Survival (CARES), United States, October 1, 2005—December 31, 2010. MMWR Surveill Summ 2011;60:1-19.
24. Merchant RM, Yang L, Becker LB, et al. Incidence of treated cardiac arrest in hospitalized patients in the United States. Crit Care Med 2011;39:2401-6.
25. Kronick SL, Kurz MC, Lin S, et al. Part 4: systems of care and continuous quality improvement: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2015;132(18 suppl 2):S397-413.
26. Owen DD, McGovern SK, Murray A, et al. Association of race and socioeconomic status with automatic external defibrillator training prevalence in the United States. Resuscitation 2018;127:100-4.
27. Blewer AL, Ibrahim SA, Leary M, et al. Cardiopulmonary resuscitation training disparities in the United States. J Am Heart Assoc 2017;6:e006124.
28. Kontopantelis E, Mamas MA, Deanfield J, Asaria M, Doran T. Excess mortality in England and Wales during the first wave of the COVID-19 pandemic. J Epidemiol Community Health 2021;75:213-23.
29. Brown TP, Booth S, Hawkes CA, et al. Characteristics of neighbourhoods with high incidence of out-of-hospital cardiac arrest and low bystander cardiopulmonary resuscitation rates in England. Eur Heart J Qual Care Clin Outcomes 2019;5:51-62.
30. Shah AS, Bhopal R, Gadd S, Donohoe R. Out-of-hospital cardiac arrest in South Asian and White populations in London: database evaluation of characteristics and outcome. Heart Br Card Soc 2010;96:27-9.

Supplementary Material

To access the supplementary material accompanying this article, visit *CJC Open* at https://www.cjcopen.ca/ and at https://doi.org/10.1016/j.cjco.2021.09.026.