Differences in incident and recurrent myocardial infarction among White and Black individuals aged 35 to 84: Findings from the ARIC Community Surveillance Study

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Abstract

Background: No previous study has examined racial differences in recurrent acute myocardial infarction (AMI) in a community population. We aimed to examine racial differences in recurrent AMI risk, along with first AMI risk in a community population.

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Conceptualization and methodology: All authors **Acquisition and interpretation of data:** All authors **Statistical analysis:** Islek and Alonso **Drafting of the manuscript:** Islek **Review and editing of the manuscript:** All authors **Supervision:** Vaccarino

Methods: The community surveillance of the Atherosclerosis Risk in Communities Study (2005–2014) included 470000 people 35–84 years old in 4 U.S. communities. Hospitalizations for recurrent and first AMI were identified from ICD-9-CM discharge codes. Poisson regression models were used to compare recurrent and first AMI risk ratios between Black and White residents.

Results: Recurrent and first AMI risk per 1000 persons were 8.8 (95% CI, 8.3–9.2) and 20.7 (95 % CI, 20.0–21.4) in Black men, 6.8 (95% CI, 6.5–7.0) and 14.1 (95 % CI, 13.8–14.5) in White men, 5.3 (95% CI, 5.0–5.7) and 16.2 (95 % CI, 15.6–16.8) in Black women, and 3.1 (95% CI, 3.0–3.3) and 8.8 (95 % CI, 8.6–9.0) in White women, respectively. The age-adjusted risk ratios (RR) of recurrent AMI were higher in Black men vs. White men (RR, 1.58 95 % CI, 1.30–1.92) and Black women vs. White women (RR, 2.09 95 % CI, 1.64–2.66). The corresponding RRs were slightly lower for first AMI: Black men vs. White men, RR, 1.49 (95 % CI, 1.30–1.71) and Black women vs. White women, RR, 1.65 (95 % CI, 1.42–1.92)

Conclusions: Large disparities exist by race for recurrent AMI risk in the community. The magnitude of disparities is stronger for recurrent events than for first events, and particularly among women.

Graphical Abstract

Differences in incident and recurrent AMI among White and Black individuals aged 35 to 84
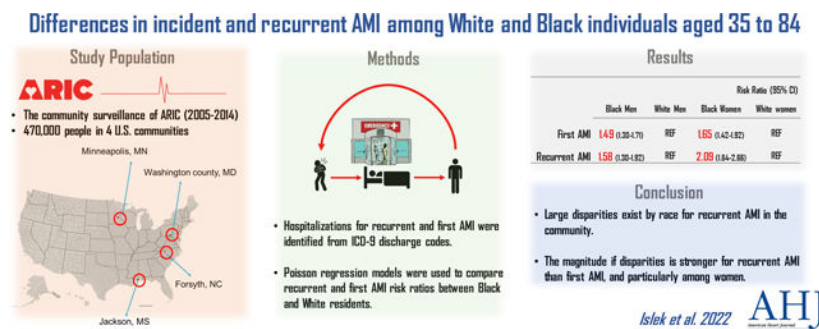
Keywords

Recurrent myocardial infarction; risk; myocardial infarction outcomes; community surveillance; racial differences; racial disparities

Introduction

Previous studies suggest that Black patients have higher 30-day and 5-year mortality following an acute myocardial infarction (AMI) than White patients[1,2]. Part of the difference in the outcome of AMI by race could reflect a higher reinfarction risk in Black patients compared with White patients. However, few studies have examined the risk of AMI recurrence by race. Furthermore, most previous studies of race differences in the outcome of AMI examined Medicare beneficiary patients 65 years of age or older[1,3–6]. Examining older patients could mask race-related differences since Black individuals tend to develop AMI and die from it earlier in life than White individuals[7]. Also, most studies did not differentiate between first occurring and recurrent AMI events[4] or examined only first AMI

events[8]. Finally, most studies relied on administrative databases without adjudication of AMI events[3,5,6] which could result in event misclassification.

Clarification of racial differences in recurrent AMI would improve understanding of race-related disparities in coronary heart diseases (CHD). In the community surveillance component of the Atherosclerosis Risk in Communities (ARIC) study, we examined the risk of recurrent AMI, overall and by race, sex, and age, and contrasted the results with the information on the risk of first AMI. We hypothesized that Black individuals have a higher risk of recurrent AMI and first AMI, compared to White individuals.

Methods

We used data from the Atherosclerosis Risk in Communities Study (ARIC) which is a prospective epidemiologic study conducted in four US communities. ARIC is designed to investigate the etiology and natural history of atherosclerosis and its clinical manifestations, and variation in cardiovascular risk factors, medical care and disease burden by race, gender, location and date. ARIC includes two parts: The Community Surveillance component and the Cohort component. For this study, we used data from the community surveillance component of the ARIC study. In the community surveillance component, four entire communities which included Forsyth County, North Carolina, the city of Jackson, Mississippi, eight northern suburbs of Minneapolis, Minnesota, and Washington County, Maryland, were systematically surveyed to describe the community-wide occurrence of hospitalized AMI and CHD deaths between years 2005 to 2014[9]. The four communities included approximately 470000 men and women aged 35–84 years.

We used "race" abstracted from the hospital medical records as the key variable of interest and categorized it as "Black individuals" vs. "White individuals." We excluded 1779 hospitalizations in Non-White and Non-Black patients, since the number of events among Non-White and Non-Black individuals was too small to produce precise estimates of event risks[10]. Sampling probabilities were reviewed periodically and modified over the surveillance period for efficiency. The methods for the sampling procedure are described in detail elsewhere[11].

Identification of recurrent and incident AMI events

Both recurrent and first AMI hospitalizations were identified from the electronic discharge lists of the 31 hospitals serving the four ARIC communities. Trained ARIC staff members abstracted medical records for sampled events and collected information on age, residence in the community, and discharge codes (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] codes 402, 410–414, 427, 428, and 518.4). The events to investigate were randomly selected within each discharge group and the sampling fraction varied by sex, race, and center[11]. Information on chest pain, level of cardiac biomarkers (total creatinine phosphokinase, creatinine phosphokinase-myocardial band, lactate dehydrogenase, and troponin) and history of AMI and other cardiovascular comorbidities (current smoking, history of hypertension and diabetes) was abstracted from the medical records. Additionally, copies of up to three ECGs of the patients were sent to a centralized reading center for independent classification using the Minnesota

code[12]. A standardized computer algorithm, based on chest pain, cardiac biomarkers, and electrocardiograms, was used to determine a computer AMI diagnosis[13]. A panel of physicians reviewed the cases to make the final diagnosis decision if the discharge diagnosis codes and the computer diagnosis did not align. A first AMI was defined as an AMI event in a person for whom the medical record either stated that there was no previous AMI or did not contain any reference to a history of AMI[14]. A recurrent AMI was defined as any 'definite or probable AMI' for which the medical record stated a history of AMI. For both the recurrent and first AMI hospitalizations, we followed standard ARIC definitions[15]. Events occurring outside the study area were not included if the community residents were not transferred to or discharged from a surveillance hospital. In the case of patients transferred from a surveillance hospital, the transferring surveillance hospital's diagnostic information was used for the events' validation[14]. The out-of-hospital CHD deaths as a result of an AMI were captured by surveying discharge lists from local hospitals and death certificates from state vital statistics. Additional information was sought from the next of kin of the deceased and other informants, from certifying doctors and family physicians, and from coroners or medical examiners.

In a secondary analysis, we examined racial differences in 28-day and 365-day case-fatality of both recurrent and first AMI. Hospitalized AMI events were linked to death certificate data provided by state health departments or the National Death Index to determine the 28-day and 365-day case-fatality of validated AMI events. The data for deaths were reviewed and assigned a diagnosis by the ARIC Mortality and Morbidity Classification Committee using standardized criteria[13]. Further details are provided in the ARIC Study Surveillance Manual[15].

Statistical Analysis

First, we tabulated the distributions of characteristics of recurrent and first AMI events by race and sex. Next, we computed hospitalized event proportions per 1000 persons and 95% confidence intervals (CI) for both recurrent and first AMI by race and sex. Annual event rates per 1000 persons specific for sex and race were computed based on population denominators estimated using interpolation and extrapolation of 1980, 1990, 2000, and 2010 United States Census population estimates. In community surveillance, ARIC does not follow persons and the surveillance data only defines an event as "recurrent AMI" or "incident AMI" based on the hospital records in the surveilled community. Therefore, we computed the risk of both incident and recurrent AMI with the surveillance population as the denominator. We used the same methodology as in the previous studies reporting risk of recurrent AMI in the community surveillance[16]. We constructed age-adjusted Poisson regression models to compare recurrent and first AMI risks in Black men vs. White men and in Black women vs. White women and tested race and sex interactions. We also examined racial differences by age group in men and women separately. For the age group analysis, we used 5-year age groups, ranging from 40–44 years to 75–79 years for both men and women. There were not enough cases for statistical testing among the 35–39 age group for Black men (n=16), White men (n=18), Black women (n=13) and White women (n=4). Similarly, the number of cases was not enough among the 80–84 age group for Black men (n=25) and Black women (n=29).

We used logistic regression to compare 28-day and 365-day case-fatality percentages of both recurrent AMI and first AMI in Black men vs. White men and in Black women vs. White women.

Since there could be significant socioeconomic differences between the poorer states (Mississippi and North Carolina) and the two wealthier states (Maryland and Minnesota), which could drive some portion of the racial differences[17], we compared the risk of recurrent AMI between Black and White individuals in a sub-analysis only including the community residents in Jackson, MS, and Forsyth County, NC.

We used established procedures for surveillance data while creating the models. We weighted all statistical models and computed standard errors by stratified random sample methodology to reflect the sampling scheme.

All analyses were conducted in SAS version 9.4. An Institutional Review Board at each site approved the ARIC study. We also obtained approval from the Emory University Institutional Review Board (IRB00111905).

Results

Characteristics of the study population

Between 2005 and 2014, after applying population weights, 13101 first and 5367 recurrent AMI hospitalizations occurred among men and women of the ARIC surveillance communities aged 35–84 years. Of the recurrent events, 957 occurred in Black men, 2444 in White men, 636 in Black women, and 1330 in White women.

The basic characteristics of recurrent AMI hospitalizations are described in Table 1. Corresponding data for the first AMI are reported in Supplementary Table 1. The mean age (S.E.) for recurrent AMI was 58.8 (0.6) years in Black men, 67.7 (0.6) years in White men, 61.1 (0.5) years in Black women, and 69.9 (0.7) years in White women. The mean age for recurrent AMI was similar to the mean age for first AMI in Black men, Black

women and in White women. AMI recurrence occurred on average at older age than the first AMI in White men. The proportion of patients who had no health insurance was twice as high among Black individuals as White individuals. Current smoking frequency, history of hypertension and history of diabetes were higher among Black patients than among White patients, both in men or women and for both recurrent and first AMI hospitalizations.

Racial differences in risk of recurrent AMI and first AMI

Table 2 shows the association of race with hospitalizations for recurrent AMI and first AMI. The risk of recurrent AMI per 1000 population was higher in Black men (8.8, 95 % CI, 8.3–9.2) than White men (6.8, 95% CI, 6.5–7.0), and in Black women (5.3, 95% CI, 5.0–5.7) than White women (3.1, 95% CI, 3.0–3.3). Comparing Black men with White men, the age-adjusted risk ratio (RR) for recurrent AMI was 1.58 (95 % CI, 1.30–1.92). The corresponding figure was 2.09 (95 % CI, 1.64–2.66) comparing Black women with White women.

The magnitude of racial differences in the risk of first AMI was smaller than the racial differences in recurrent AMI risk, especially for women. Comparing Black men with White men, the RR for the first AMI was 1.49 (95% CI, 1.30–1.71) and comparing Black women with White women, it was 1.65 (95% CI, 1.42–1.92). There were no significant race and sex interactions for the recurrent or first AMI in age-adjusted Poisson models.

Racial differences in risk of recurrent AMI among age groups

Figure 1 illustrates racial differences in recurrent AMI risk among different age groups by sex. The age-adjusted RR of recurrent AMI in Black vs. White individuals was higher in magnitude among the younger age groups and declined among older age groups among both men and women. In both men and women, the risk of recurrent AMI was higher in Black individuals than White individuals up to age 70 years. In men, the excess risk in Black persons declined gradually with age and became lower than White persons in the oldest age group (75–79 years). In Black women, however, the risk of recurrent AMI was still higher than White women in the age group 75–79 years. There was a significant interaction between race and age ($p < 0.001$).

Racial differences in the 28- and the 365-day case-fatality percentage of recurrent AMI

Table 3 compares 28-day and 365-day case-fatality percentages for recurrent and first AMI between Black and White individuals. For recurrent AMI, neither the 28- nor the 365-day age-adjusted case-fatality was elevated in Black men than in White men (respectively, OR, 0.88, 95% CI, 0.48–1.61 and OR, 0.79, 95% CI, 0.52–1.22). In contrast, for first AMI, both the 28-day and 365-day age-adjusted case-fatality were higher in Black men than in White men (respectively, OR, 1.29, 95% CI, 1.18–1.40 and OR, 1.93, 95% CI, 1.43–2.60). For both recurrent and first AMI, the 28- and 365-day case-fatality was at least nominally higher in Black women than in White women (Table 3).

In sub-analysis where we only included the community residents in Jackson, MS, and Forsyth County, NC, there was a slight change in the risk ratios of recurrent AMI for both

men (RR, 1.99 95 %CI, 1.63–2.45) and women (RR,1.83, 95 % CI,1.43–2.34), however, our conclusions remained the same.

Discussion

In this community-based surveillance study, the risk of recurrent AMI was higher in Black than in White individuals both among men and women. Age-adjusted racial differences in recurrent AMI were higher in magnitude among younger age groups and were no longer evident among people aged 70 years and over. Our analysis also suggests that the magnitude of the racial differences in the risk of recurrent AMI is more pronounced than the racial differences in the risk of first AMI, particularly among women.

Earlier studies have reported declining trends in recurrent AMI[3,4,16]. However, previous analyses in Medicare populations indicate that these declines were less in Black individuals compared to White counterparts[5,18,19]. Our findings also highlighted racial disparities and extend these previous analyses to the population aged 35–84 years, as this is the first study of race differences in reinfarction in the broad community. This is important since limiting the analysis to older adults may mask racial disparities since Black individuals tend to have a fatal AMI earlier in life than their White counterparts[7,20]. Our analysis additionally suggests that racial differences in recurrent AMI are more pronounced among women and younger age groups.

Several factors could explain racial disparities in recurrent AMI. First, patient-level risk factors and existing pre-AMI health status could play a role. Reports from large clinical databases have suggested that racial differences in mortality and readmission after the index AMI could be attributable to patient-related factors, such as cardiovascular risk factors and comorbidities[1,21,22]. A recent analysis of the REGARDS cohort study also suggested that racial disparities in cardiovascular events (as a composite outcome) after a first AMI are largely dependent on differences in pre-admission health history and clinical characteristics of the AMI[8]. Black individuals have a higher prevalence of cardiovascular risk factors such as hypertension, diabetes, and obesity than White individuals in the community[23]; therefore, racial disparities in the first occurrence of a AMI could be explained by these patient-level differences[24]. However, our study shows that racial differences persist for the recurrence of an AMI, and the disparity is actually magnified. Since Black individuals have significantly more comorbidities than White individuals and these comorbidities tend to have a time-dependent impact on cardiovascular health[25], our results implicate differences by race in access to secondary prevention opportunities after both the first AMI and subsequent AMIs. Indeed, some studies have suggested that racial disparities in AMI outcomes could be explained by differences in use of secondary prevention therapies[6,26]. A recent data analysis from 400 US hospitals suggests that Black patients are less likely to receive several types of preventive approaches than Whites, such as smoking cessation counseling, and therapies such as clopidogrel[27]. Also, previous literature suggests that Black patients with AMI are less likely than White patients to receive invasive coronary interventions[28,29], which could play a role in disparities in recurrent AMI risk.

Other factors could explain racial differences in risk of recurrent AMI. Physician bias, attitudes, and patients' perceptions of their own health could contribute to differences in follow-up care[30,31]. Also, participation in cardiac rehabilitation, which is associated with lower mortality after an AMI[32], could play a role since Black people are less likely to participate in and get a referral to cardiac rehabilitation after an AMI compared to White counterparts[33,34]. Furthermore, Black individuals are reported to be less aware of the symptoms of an AMI and less likely to call emergency services in the setting of an AMI than White individuals[35]. This could perhaps result in delays to access to health care and could contribute to worse outcomes after the first AMI, possibly increasing the likelihood of a recurrent AMI in Black individuals compared to White individuals.

Our findings extend the literature of racial disparities in recurrent AMI from predominantly elderly populations (e.g., Medicare populations) to younger age groups. In our study, the racial difference among men in recurrent AMI was seen only among younger patients. The risk of AMI was similar in Black men and White men around age 70 years and was even lower among Black men than White men after age 75 years. Among women, the risk of recurrent AMI was similar around age 70 years, however, was still higher in Black women than White women in the age group 75–79 years. A previous study reported that racial differences in hospital death after AMI are larger among younger as opposed to older patients[36]. Since Black individuals tend to develop CHD at younger age and die from it earlier in life than Whites[7], this "race-crossover effect" could mask a survivorship bias, such that Black persons developing CHD at older age may represent a more resilient group[20].

In our study, both 28- and 365-day case-fatality of recurrent AMI tended to be higher in Black women than in White women, similar to the case fatality for first AMI. Among men, however, only the case fatality of a first AMI was significantly elevated in Black individuals. It is possible that differences by race and sex in the use of early treatments after a first AMI contribute to mortality differences for the initial event[28,37–39] while a possible survivorship bias could attenuate differences in case fatality of recurrent AMI, especially among men[20].

Our study has several strengths, including the large sample size, the inclusion of younger age groups (beginning at age 35 years), the independent event validation which minimizes misclassification, and the utilization of a decade-long surveillance system in a multi-community-based setting. Our study also has some limitations. Since participants in the Jackson site were predominantly Black participants, and participants in the Minnesota and Maryland sites were predominantly White participants, we were not able to fully separate differences by race from differences by study site. Also, since this was a community surveillance study, and ARIC did not follow up all community residents, there were no data on patient-level socioeconomic and pre-event cardiovascular risk factors, except for information abstracted from the medical records for the AMI hospitalization (smoking and history of hypertension and diabetes). Race information was derived from the medical records and was not self-reported as suggested by recent guidelines for health disparities research[40,41]. Also, we were not able to adjust for risk factors abstracted from the medical records in the models, since the events were sampled for surveillance based only on sex, race, and age group and sampling probabilities were not available for risk factors. We could have missed some events since we were not able to include events occurring outside the

surveillance study area if there was no transfer or discharge from a surveillance hospital. Finally, the ARIC surveillance study did not provide data on post-discharge factors that might influence the recurrence and the case fatality of AMI, such as receipt of preventive treatments or physician follow-up after discharge, which will need to be considered in future patient-level cohort studies. Examining the role of comorbidities and socioeconomic factors in racial disparities using methods like sequential modelling would be needed in future studies. If available, post-AMI discharge data, such as follow-up care, could be instrumental in understanding the observed disparities.

Conclusions

In conclusion, we found large disparities by race for recurrent AMI risk in the community. The magnitude of these disparities is stronger for recurrent events than for first events. Also, these differences seem to be more marked in the younger population in both men and women. Our results suggest opportunities to improve care and reduce disparities by maximizing access to secondary prevention strategies after the first AMI for all patients. These interventions should specifically target younger populations to narrow the racial gap in the outcome of AMI. Further studies are needed to investigate how the socioeconomic factors would impact on the association of race and recurrent AMI.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

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Highlights

- Racial disparities exist for recurrent acute myocardial infarction risk in community

- The magnitude of disparities is stronger for recurrent events than for first events

- Racial differences are more marked in the younger population both in men and women
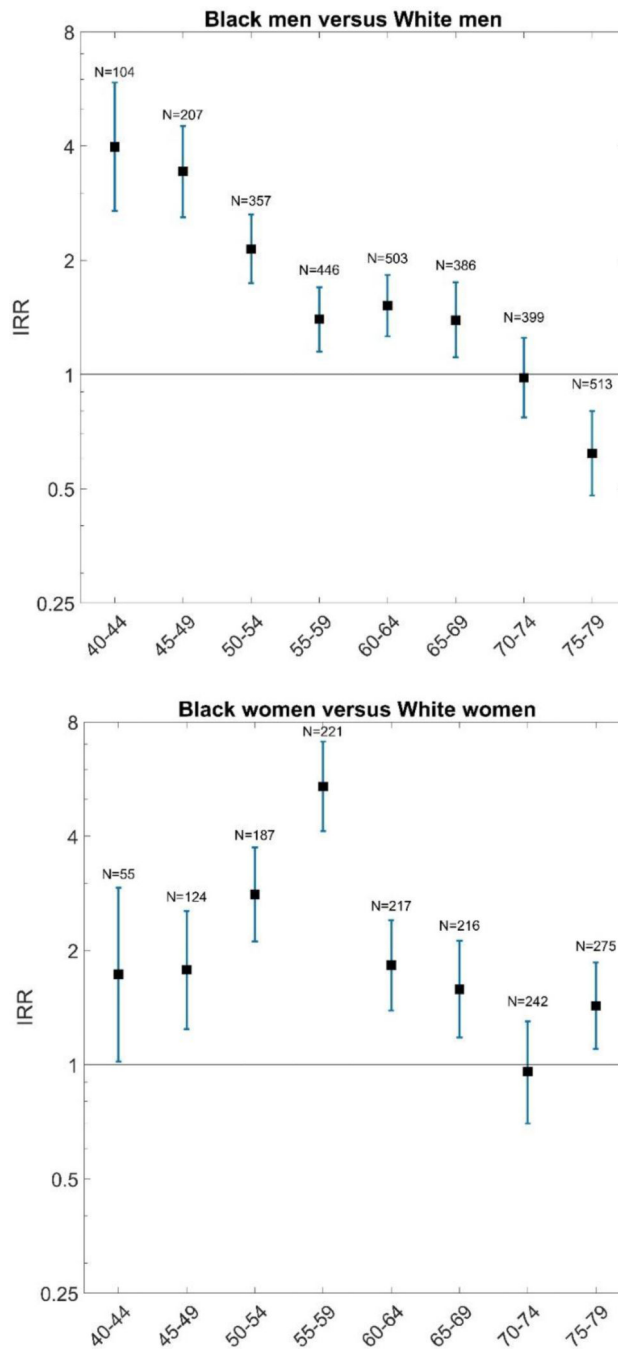
Figure 1.
Racial differences in recurrent AMI risk by age group and sex in the ARIC Community Surveillance Study

The N reported above the RR reflects the total number of observations in each specified age group.

Among women, age brackets were collapsed to allow for a sufficient number of events.

Abbreviation: RR: risk ratio

Table 1.

Characteristics by race and sex of the patients who were hospitalized for a recurrent AMI event in the ARIC Community Surveillance Study

	Black Men	White Men	Black Women	White Women
Actual number of cases	395	835	278	553
Weighted number of cases [*]	957	2444	636	1330
Age, mean (SE)	58.8 (0.6)	67.7 (0.6)	61.1 (0.5)	69.9 (0.7)
Health insurance status N (%)				
No insurance	139 (16 %)	136 (7 %)	55 (9 %)	39 (4 %)
Medicare	298 (35 %)	1054 (52 %)	264 (45 %)	664 (63 %)
Medicaid	231 (27 %)	140 (7 %)	174 (30 %)	89 (8 %)
Prepaid insurance or health plan	133 (16 %)	624 (31 %)	76 (13 %)	222 (21 %)
Other	47 (6 %)	89 (4 %)	19 (3 %)	35 (3 %)
Smoking history N (%)				
Current	415 (44 %)	853 (36 %)	185 (29 %)	302 (23 %)
Never	273 (29 %)	545 (23 %)	321 (51 %)	547 (42 %)
Past smoker	248 (27 %)	991 (41 %)	124 (20 %)	462 (35 %)
Comorbidities N (%)				
History of hypertension	884 (92 %)	2100 (86 %)	602 (95 %)	1156 (87 %)
History of diabetes	483 (50 %)	376 (15 %)	385 (60 %)	294 (22 %)

[*] Distribution of characteristics by race and sex of patients are given based on weighted number of cases

Table 2.

Association of race with recurrent and first myocardial infarction risk stratified by sex in the ARIC Community Surveillance Study

	Black Men	**White Men**	**Black Women**	**White women**
Population size	109301	362019	119730	429977
Recurrent AMI				
Actual number of cases	395	835	278	553
Weighted number of cases [*]	957	2444	636	1330
Hospitalized event proportion per 1000 persons (95 % CI)	8.8 (8.3–9.2)	6.8 (6.5–7.0)	5.3 (5.0–5.7)	3.1 (3.0–3.3)
Risk Ratio [†] (95% CI)	1.58 (1.30–1.92)	**ref**	2.09 (1.64–2.66)	**ref**
First AMI				
Actual number of cases	2259	5119	1939	3784
Weighted number of cases [*]	987	1869	789	1602
Hospitalized event proportion per 1000 persons (95 % CI)	20.7 (20.0–21.4)	14.1 (13.8–14.5)	16.2 (15.6–16.8)	8.8 (8.6–9.0)
Risk Ratio [†] (95% CI)	1.49 (1.30–1.71)	**ref**	1.65 (1.42–1.92)	**ref**

[*] Hospitalized event proportion per 1000 persons and risk ratios are estimated based on the weighted number of cases

[†] Risk ratio is estimated using a Poisson regression model adjusted for age

Table 3.

Racial differences in 28- and 365-day case-fatality percentages of recurrent and first acute myocardial infarction stratified by sex in the ARIC Community Surveillance Study

	Black Men	White Men	Black Women	White Women
Recurrent AMI				
Actual number of cases	395	835	278	553
Weighted number of cases	957	2444	636	1330
28-day case-fatality				
Actual number of fatal events	29	90	30	77
Weighted number of fatal events [*]	53	199	54	131
Case-fatality %	5.54 (4.44–6.88)	8.14 (7.28–9.09)	8.49 (6.84–10.49)	9.85 (8.59–11.28)
OR [†] (95% CI)	0.88 (0.48–1.61)	ref	1.44 (0.74–2.83)	ref
365-day case-fatality				
Actual number of fatal events	62	178	55	137
Weighted number of fatal events [*]	126	497	117	263
Case-fatality %	13.16 (11.47–15.07)	20.35 (19.03–21.71)	18.40 (16.01–21.06)	19.77 (18.04–21.63)
OR [†] (95% CI)	0.79 (0.52–1.22)	ref	1.40 (0.85–2.30)	ref
First AMI				
Actual number of cases	2259	5119	1939	3784
Weighted number of cases	987	1869	789	1602
28-day case-fatality				
Actual number of fatal events	91	174	74	158
Weighted number of fatal events [*]	165	344	160	357
Case-fatality %	7.29 (6.45–8.26)	6.72 (6.17–7.32)	8.25 (7.28–9.34)	9.43 (8.68–10.25)
OR [†] (95% CI)	1.29 (1.18–1.40)	ref	1.25 (0.82–1.92)	ref
365-day case-fatality				
Actual number of fatal events	166	260	132	264
Weighted number of fatal events [*]	358	584	316	619
Case-fatality %	15.85 (14.62–17.15)	11.41 (10.70-12.16)	16.30 (14.96–17.72)	16.36 (15.39–17.37)
OR [†] (95% CI)	1.93 (1.43–2.60)	ref	1.46 (1.05–2.02)	ref

Abbreviations: OR: odds ratio AMI: acute myocardial infarction

[*] Case fatality % and odds ratios are estimated based on the weighted number of events

[†] Odds ratios are estimated using an age-adjusted logistic regression model. Survey logistic procedure was used.