Sex and Racial/Ethnic Disparities in Outcomes After Acute Myocardial Infarction

A Cohort Study Among Members of a Large Integrated Health Care Delivery System in Northern California

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Background: Previous studies have documented sex and racial/ethnic disparities in outcomes after acute myocardial infarction (AMI), but the explanation of these disparities remains limited. In a setting that controls for access to medical care, we evaluated whether sex and racial/ethnic disparities in prognosis after AMI persist after consideration of socioeconomic background, personal medical history, and medical management.

Methods: We conducted a prospective cohort study of the members (20 263 men and 10 061 women) of an integrated health care delivery system in northern California who had experienced an AMI between January 1, 1995, and December 31, 2002, and were followed up for a median of 3.5 years (maximum, 8 years). Main outcome measures included AMI recurrence and all-cause mortality.

Results: In age-adjusted analyses relative to white men, black men (hazard ratio [HR], 1.44; 95% confidence interval [CI], 1.26-1.65), black women (HR, 1.47; 95% CI, 1.26-1.72), and Asian women (HR, 1.37; 95% CI, 1.13-1.65) were at increased risk of AMI recurrence. However, multivariate adjustment for sociodemographic background, comorbidities, medication use, angiography, and revascularization procedures effectively removed the excess risk of AMI recurrence in these 3 groups. Similarly, the increased age-adjusted risk of all-cause mortality seen in black men (HR, 1.55; 95% CI, 1.37-1.75) and black women (HR, 1.45; 95% CI, 1.27-1.66) was greatly attenuated in black men and reversed in black women after full multivariate adjustment.

Conclusion: In a population with equal access to medical care, comprehensive consideration of social, personal, and medical factors could explain sex and racial/ethnic disparities in prognosis after AMI.

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Many studies in the United States and abroad have observed differences in clinical presentation, prognosis, and treatment of cardiovascular disease, depending on the patient's sex and race/ethnicity.[1,2] In particular, previous work focusing on sex differences has shown that women with obstructive coronary artery disease experience worse prognosis after acute myocardial infarction (AMI) compared with men.[3-5] This phenomenon has been at least partially attributed to the fact that women tend to present with symptomatic coronary artery disease 10 years later than men and therefore tend to have a higher burden of comorbid conditions, and to differences in the use of cardiac procedures between women and men.[6-8] In turn, previous research on ethnic disparities in the United States has demonstrated that black women tend to have higher death rates related to coronary disease than do white women.[1,9] On the other hand, evidence of white-black differences in coronary disease mortality in men is more mixed. Although some studies found that black men experienced significantly less coronary disease mortality than white men,[10] others have found that black men had a greater short-term case fatality rate after coronary events compared with white men[11] and that treated young black patients with hypertension (despite a lower AMI incidence) had higher AMI mortality than did white counterparts.[12]

Various mechanisms have been proposed to explain these differences, including genetic, behavioral, environmental, social, and medical care variables such as medical management, invasive procedures, poor communication with minority patients, and racial bias on the part of heath care professionals. However, the causes of racial/ethnic disparities in cardiovascular health are complex and remain incompletely understood.[13-18] To further complicate this picture, few prospective data exist on outcomes after AMI among other racial/ethnic groups, namely Asians and Hispanics.

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We took advantage of a unique opportunity to use comprehensive data from a large integrated health care delivery system and from the 2000 US Census and investigate the following 2 research questions: (1) In a setting that controls for access to health care, are there sex and racial/ethnic disparities in prognosis after AMI across men and women in the 4 main ethnic groups (white, black, Hispanic, and Asian)? (2) To what extent are these sex and racial/ethnic disparities in prognosis after AMI explained by differences in socioeconomic background, personal medical history, and medical management?

METHODS

STUDY COHORT

We identified all members of Kaiser Permanente of northern California aged 30 to 85 years who were discharged alive after being hospitalized for AMI (as ascertained by a primary discharge diagnostic code 410.x) between January 1, 1995, and December 31, 2002, in 1 of the 16 northern California Kaiser Permanente hospitals (from computerized medical services utilization data) or in out-of-plan hospitals (from claims data). This ascertainment method has 96% specificity based on the presence of 2 of the following 3 modified World Health Organization criteria: (1) ischemic symptoms, (2) electrocardiographic changes, and (3) enzyme or pathological evidence of infarction, using medical chart review and laboratory data as gold standard data sources.[19]

The Kaiser Permanente Medical Care Program (KPMCP) of northern California is a group practice prepaid health care plan that is the largest and one of the oldest health maintenance organizations in the United States. The KPMCP currently provides comprehensive medical services through 16 hospitals and 23 outpatient clinics to more than 3.2 million members in a 14-county region of northern California that includes the San Francisco Bay and Sacramento metropolitan areas. Approximately 30% of the general population in the geographic areas served belongs to the KPMCP. As determined from a membership survey of a sample of the northern California KPMCP, the sociodemographic characteristics of the members are generally representative of the underlying population, except with respect to income, where KPMCP members somewhat underrepresent the very poor and the very wealthy.[20] The KPMCP membership also differs somewhat with respect to education, with 63% high school graduates compared with 56% in the general population. The estimated racial composition of the overall membership (estimated by the 2002 Member Health Survey) is quite close to that of the 2000 US Census–enumerated population in the San Francisco Bay metropolitan statistical area.[21] The KPMCP vs San Francisco Bay metropolitan statistical area ethnic composition is as follows: 66% vs 58% white, 6% vs 8% black, 16% vs 19% Asian, and 12% vs 15% other. Although 19% of the San Francisco Bay metropolitan statistical area self-identifies as Hispanic/Latino, 11% of the KPMCP does. By source of insurance coverage, the membership is 78.5% commercial (mostly through employment), 11% Medicare, 2.5% MediCal and other special programs, and 8% self-pay.

Age and sex were obtained from the patient's demographics file. Race/ethnicity information was obtained from several complementary and overlapping sources, including research surveys (ie, self-reported ethnicity) and inpatient electronic records (ie, assigned ethnicity). We preferentially used self-reported ethnicity when available (in 55% of the cohort); otherwise, we used the race/ethnicity as assigned by a health care professional in the inpatient record. In a previous validation study among more than 350 000 KPMCP members with race/ethnicity available from multiple sources, including assigned ethnicity in inpatient records, the agreement between the inpatient records and 3 distinct sources of self-reported ethnicity (ie, the 1994-2001 Member Patient Survey, the 1979-1985 Multiphasic Health Checkup, and the 1999 Member Health Survey) was 93.4%, 94.9%, and 95.3%, respectively. No information was available at the individual level on educational attainment, household income, or health behaviors such as habitual diet, alcohol consumption, or physical activity. To obtain sociodemographic characteristics, we assigned a geocode to each member of the cohort using MapMarker Plus version 9.1 software (MapInfo Corporation, Troy, NY) and we then extracted information at the block group level from the US Census 2000[22] on selected variables in the following 4 domains: (1) race/ethnicity; (2) marital status (percentage of married persons among those 15 years and older); (3) economic factors (median household income, percentage of households below poverty level, and home ownership); and (4) education attainment/occupational status (percentage with completed college or higher among adults 25 years and older and percentage of population with predominantly working-class occupation among civilians).

History of coronary heart disease (including revascularization procedures), stroke, and heart failure was ascertained with hospital discharge and inpatient procedures data going back to 1979. Presence of diabetes mellitus was ascertained using the Kaiser Permanente northern California Division of Research Diabetes Registry, a database that captures all diabetic patients in the KPMCP with a sensitivity of 98%.[19] Other comorbid conditions (hypertension, depression, chronic obstructive pulmonary disease [COPD], and asthma) were ascertained using hospitalization archived data and the automated outpatient services clinical records, which became operational in 1995 and include emergency department visits. Using real-time computerized pharmacy data, we retrospectively identified all cardiovascular, asthma, and antidepressant medications dispensed during the study period. The cardiovascular disease medication classes included nitrates, agents to lower cholesterol levels, angiotensin-converting enzyme inhibitors, anticoagulants/antiplatelet agents (excluding aspirin), calcium channel blockers, antiadrenergics, antiarrhythmics, and angiotensin antagonists. Recurrence of AMI, angiography, and revascularization procedures, including percutaneous transluminal coronary angioplasty and bypass surgery, during follow-up or the index hospitalization was ascertained using inpatient databases of all hospitalizations occurring at any of the 16 KPMCP hospitals in northern California plus out-of-plan hospitalizations, the latter captured using an automated database of claims (about 12% of recurrent AMI events were captured using this database). We used diagnosis and procedure codes from the *International Classification of Diseases, Ninth Revision, Clinical Modification*[23] (primary code, 410.x for AMI) and corresponding *Current Procedural Terminology* codes for angiography and revascularization procedures, respectively). The full diagnostic record is usually completed within 1 to 2 months after discharge. Deaths from 1995 through the end of the study were ascertained using the California Automated Mortality Linkage System, which has a sensitivity of 0.97 compared with the National Death Index.[24] The presumed underlying cause of death was also categorized according to codes from the *International Classification of Diseases, Ninth Revision*,[25] and, starting in 1999, codes from *International Statistical Classification of Diseases, 10th Revision*.[26] The study was approved by the Kaiser Foundation Research Institute's institutional review board.

STATISTICAL ANALYSIS

Statistical analysis was conducted using SAS software, version 8.2 (SAS Institute Inc, Cary, NC). Bivariate analysis was per-

Table 1. Sociodemographic Characteristics of the Male Cohort by Race*

Characteristic	Racial Groups (N = 20 263)			
	White	Black	Asian	Hispanic
Total population, No. (%)	15 905 (78)	1334 (7)	1686 (8)	1338 (7)
Age, y	64 (65; 12)	61 (61; 11)	60 (60; 12)	62 (63; 11)
Age range, No. (%), y				
30-44	792 (5)	102 (8)	170 (10)	73 (5)
45-54	2798 (18)	271 (20)	400 (24)	275 (21)
55-64	4182 (26)	431 (32)	506 (30)	392 (29)
65-74	4565 (29)	338 (25)	388 (23)	406 (30)
≥75	3568 (22)	192 (14)	222 (13)	192 (14)
Type of coverage, No. (%)				
Commercial	7688 (48)	899 (67)	1076 (64)	763 (57)
Medicare	7148 (45)	381 (29)	462 (27)	514 (38)
Self-pay	941 (6)	29 (2)	110 (7)	53 (4)
MediCal/special programs	39 (0.2)	11 (1)	20 (1)	2 (0)
Census block groups, No.†	5354	929	1189	1105
Race/ethnicity, %				
Asian	13 (8; 15)	17 (12; 16)	27 (22; 19)	17 (11; 16)
Black	5 (2; 9)	20 (12; 20)	8 (3; 11)	7 (3; 10)
Hispanic/Latino	19 (13; 17)	21 (16; 17)	18 (13; 15)	28 (21; 21)
White	58 (62; 24)	37 (33; 26)	43 (42; 24)	44 (44; 25)
Marital status, % married	54 (54; 12)	48 (49; 13)	54 (54; 12)	53 (53; 11)
Annual household income, $	60 373 (55 580; 27 293)	51 886 (48 438; 22 184)	66 006 (62 857; 26 977)	57 345 (55 066; 22 398)
Households below poverty level, %	9 (6; 8)	12 (9; 10)	8 (5; 8)	9 (7; 9)
Completed college or higher education, %	31 (26; 20)	25 (20; 18)	34 (31; 19)	24 (20; 16)
Working-class occupation, %	58 (59; 16)	64 (67; 16)	57 (59; 17)	64.0 (65.6; 14.4)

*Data are from northern California Kaiser Permanente Medical Care Program, 1995-2002. Unless otherwise indicated, data are expressed as mean (median; SD). For all categories, differences between racial groups were significant at $P<.001$.
†Indicates the unit of analysis with which the statistics presented for the census variables are calculated.

formed using analysis of variance for continuous, normally distributed variables, Kruskal-Wallis nonparametric analysis of variance for continuous skewed variables, and the χ^2 test for categorical variables. Age-adjusted rates of AMI recurrence and death from any cause, by sex and racial/ethnic groups, were estimated using Poisson regression. Person-time was calculated as years elapsed from entry into the cohort (admission date for first or index AMI) to nonfatal or fatal AMI, death by any other cause, closing date (December 31, 2002), or termination of KPMCP membership, whichever occurred first. The termination of KPMCP membership was determined as failure to appear in the monthly flag membership roster, with censoring date at the beginning of the month, ignoring any membership gaps during the study period. The median follow-up time was 3.5 years (maximum, 8 years). A series of 3 proportional hazards regression models was used to model the association between joint categories of sex and race/ethnicity (with white men as the reference group) and hazard of AMI recurrence and all-cause mortality, with increasing level of multivariate adjustment. Model 1 adjusted for age and type of coverage; model 2 further adjusted for sociodemographic characteristics; and model 3 further adjusted for individual comorbidities (coronary heart disease, hypertension, diabetes, depression, COPD, asthma, stroke, and heart failure), medication use, angiography, and revascularization procedures performed during follow-up. To avoid collinearity within sociodemographic domains, we selected 1 census variable within each of the 4 domains (race/ethnicity, marital status, economic status, and educational-occupational status) on the basis of best model fit according to the Akaike Information Criterion (defined as the $-2 \times$ log-likelihood value for the model, plus $2\times$ number of variables).[27] Median household income and percentages of married persons 15 years or older, persons 25 years or older who had completed college or higher education, and white patients were selected for the analysis of AMI recurrence; percentages of households below poverty level, married persons 15 years or older, civilians in predominantly working-class occupation, and white patients were selected for the analysis of all-cause mortality. Comorbidities, medication use, angiography, and revascularization procedures were modeled as time-dependent covariates. Indicator variables for missing values were used as required.

RESULTS

During the 8-year study starting January 1, 1995, 33 637 AMI index or entry events (defined by date of hospital admission) were identified among KPMCP members aged 30 through 85 years. Of those, the following were sequentially excluded: 86 with hospital discharge after December 31, 2002, 380 with no health care plan information after the index event, 2025 with no available information or inconsistent information on sex or race/ethnicity, 696 with absent or incomplete address, 117 with residency outside northern California, and 9 with missing census information. These exclusions left 30 324 persons (20 263 men and 10 061 women) who were discharged alive after being hospitalized for AMI.

There were marked differences in age and sociodemograhic characteristics across sex and racial/ethnic groups (**Table 1** and **Table 2**). Among men admitted for AMI, white patients were the oldest (mean age, 64 years) and Asian patients were the youngest (mean age, 60 years). Among women, white patients were also the oldest (mean

Table 2. Sociodemographic Characteristics of the Female Cohort by Race*

Characteristic	Racial Groups (N = 10 061)			
	White	Black	Asian	Hispanic
Total population, No. (%)	7929 (79)	954 (9)	614 (6)	564 (6)
Age, y	69 (71; 11)	64 (65; 12)	66 (67; 11)	66 (67; 10)
Age range, No. (%), y				
30-44	196 (2)	58 (6)	25 (4)	18 (3)
45-54	799 (10)	170 (18)	81 (13)	63 (11)
55-64	1478 (19)	226 (24)	137 (22)	141 (25)
65-74	2581 (33)	269 (28)	241 (39)	206 (37)
≥75	2875 (36)	231 (24)	130 (21)	136 (24)
Type of coverage, No. (%)				
Commercial	2513 (32)	498 (52)	252 (41)	219 (39)
Medicare	4967 (63)	388 (41)	298 (49)	320 (57)
Self-pay	378 (5)	19 (2)	26 (4)	17 (3)
MediCal/special programs	36 (0)	35 (4)	29 (5)	3 (1)
Census block groups, No.†	3837	663	527	517
Race/ethnicity, %				
Asian	13 (8; 14)	17 (13; 16)	27.2 (22.7; 19.9)	16 (11; 15)
Black	5 (2; 8)	26 (19; 22)	8.0 (4.4; 10.0)	7 (3; 10)
Hispanic/Latino	19 (13; 16)	23 (18; 17)	18.8 (14.8; 15.3)	29 (23; 21)
White	59 (64; 24)	29 (25; 23)	41.4 (38.8; 23.3)	44 (42; 24)
Marital status, % married	54 (54; 12)	46 (46; 13)	52 (52; 12)	51 (52; 11)
Annual household income, $	59 388 (55 665; 25 540)	47 865 (44 219; 21 191)	62 728 (61 146; 23 579)	55 239 (54 125; 20 095)
Households below poverty level, %	8 (6; 8)	14 (11; 11)	8 (6; 7)	10 (7; 9)
Completed college or higher education, %	30 (26; 19)	22 (17; 17)	31 (28; 18)	24 (20; 16)
Working-class occupation, %	58 (60; 16)	66 (69; 15)	60 (62; 16)	64.0 (66.2; 14.2)

*Data are from northern California Kaiser Permanente Medical Care Program, 1995-2002. Unless otherwise indicated, data are expressed as mean (median; SD). For all categories, differences between racial groups were significant at $P<.001$.
†Indicates the unit of analysis with which the statistics presented for the census variables are calculated.

age, 69 years), and black patients were the youngest (mean age, 64 years). Compared with other sex and racial/ethnic groups, white men and women were more likely to be covered by Medicare and less likely to be covered by commercial insurance. White men and women, compared with men and women of other ethnicities in the cohort, tended to live in census block groups with less racial/ethnic diversity; on the other hand, black, Asian, and Hispanic patients tended to live in census block groups with greater racial/ethnic diversity. Relative to other racial/ethnic groups, black men and women were more likely to live in census block groups with the lowest proportion of married persons, lowest median household income and home ownership, and highest proportion of households below poverty level. On the other hand, Asian men and Asian women tended to live in census block groups with the highest median household income and lowest proportion of households below poverty level. The black women's census block group of residence ranked the lowest in terms of educational level and highest in terms of working-class occupational status, whereas the Asian men's census block group of residence ranked the highest in terms of educational level and lowest in terms of working-class occupational status.

Table 3 shows the median and range of area-based characteristics of the northern California KPMCP. For instance, there were wide differences in the median proportion of white patients (37% in Oakland vs 81% in San Rafael), in households below poverty level (4% in Walnut Creek vs 12% in Fresno), and higher educational attainment (completion of college or higher, 13% in Fresno vs 47% in Redwood City).

Among men and women, prevalent hypertension, depression, stroke, and heart failure were highest in black subjects; coronary heart disease and diabetes were highest in Hispanic/Latino subjects, and small differences were observed across race/ethnicity in COPD (**Table 4** and **Table 5**). Although no differences were observed in men, prevalent asthma tended to be higher in black women compared with the women of other ethnicities. We did not observe large differences in incident or newly developed comorbidities across racial/ethnic groups in either sex (most differences were below 5%).

Except for asthma and COPD agents in men, all medication use differed by race/ethnicity in both sexes. White men had the highest use of anticoagulants/antiplatelet agents and antiarrhythmics and the lowest use of angiotensin-converting enzyme inhibitors, calcium channel blockers (together with Asian men), and angiotensin antagonists. Black men had the highest use of antiadrenergics. Asian men had the highest use of β-blockers and agents to lower cholesterol levels and the lowest use of antidepressants and miscellaneous cardiac agents. White women had the highest use of antidepressants (along with Hispanic women) and miscellaneous cardiac agents and the lowest use of antiadrenergics. Black women showed the highest use of nitrates/vasodilators, angiotensin-converting enzyme inhibitors, and calcium channel blockers and the lowest use of agents to lower cholesterol levels, anticoagulants/antiplatelet agents, and antiarrhyth-

Table 3. Sociodemographic Area-Based Characteristics of KPMCP*

Characteristic	Overall Median in the 16 Facility Areas	KPMCP Facility Area, Median	
		Minimum Median	Maximum Median
Race/ethnicity, %			
Asian	9	Santa Rosa, 2	South San Francisco, 26
Black	3	Santa Rosa, 1	Oakland, 14
Hispanic/Latino	14	San Rafael, 8	Fresno, 33
White	59	Oakland, 37	San Rafael, 81
Marital status, % married	54	Oakland, 46	Walnut Creek, 58
Annual household income, $	56 370	Fresno, 36 351	Redwood City, 76 414
Households below poverty level, %	6	Walnut Creek, 4	Fresno, 12
Completed college or higher education, %	26	Fresno, 13	Redwood City, 47
Working class occupation, %	60	Redwood City, 46	Stockton, 67

Abbreviation: KPMCP, Kaiser Permanente Medical Care Program.
*Based on 2000 US Census data. Analysis was performed with the census block group as unit of analysis, and by assigning census block groups where members of the cohort live to facility areas.

Table 4. Clinical Characteristics of the Male Cohort by Race*

Characteristic	Racial Group, No. (%) (N = 20 263)				*P* Value
	White (n = 15 905)	Black (n = 1334)	Asian (n = 1686)	Hispanic (n = 1338)	
Prevalent comorbidities					
Coronary heart disease	348 (2)	303 (23)	270 (16)	351 (26)	<.001
Hypertension	6714 (42)	796 (60)	830 (49)	608 (45)	<.001
Diabetes mellitus	3816 (24)	466 (35)	31 (31)	557 (42)	<.001
Depression	3623 (23)	360 (27)	300 (18)	259 (19)	<.001
COPD	4066 (26)	336 (25)	390 (23)	315 (24)	.08
Asthma	1359 (9)	125 (9)	163 (10)	116 (9)	.36
Stroke	1101 (7)	118 (9)	95 (6)	83 (6)	.004
Heart failure	765 (5)	118 (9)	68 (4)	67 (5)	<.001
Incident comorbidities					
Coronary heart disease	5736 (36)	500 (37)	561 (33)	504 (38)	.04
Hypertension	3817 (24)	258 (19)	401 (24)	378 (28)	<.001
Diabetes	1175 (7)	83 (6)	158 (9)	109 (8)	.005
Depression	3044 (19)	271 (20)	247 (15)	271 (20)	<.001
COPD	1812 (11)	139 (10)	150 (9)	172 (13)	.003
Asthma	738 (5)	65 (5)	64 (4)	63 (5)	.42
Stroke	780 (5)	100 (7)	63 (4)	64 (5)	<.001
Heart failure	1235 (8)	134 (10)	111 (7)	126 (9)	<.001
Medication use at discharge or anytime thereafter					
β-Blockers	13 423 (84)	1134 (85)	1472 (87)	1148 (86)	.01
Nitrates and vasodilators	12 854 (81)	1122 (84)	1368 (81)	1106 (83)	.01
Agents to lower cholesterol levels	12 425 (78)	1004 (75)	1405 (83)	1069 (80)	<.001
ACE inhibitors	10 092 (63)	915 (69)	1083 (64)	902 (67)	<.001
Anticoagulants and antiplatelet agents	7957 (50)	631 (47)	793 (47)	619 (46)	.003
Calcium channel blockers	4800 (30)	569 (43)	514 (30)	412 (31)	<.001
Antidepressants	4742 (30)	330 (25)	298 (18)	360 (27)	<.001
Antiadrenergics	3480 (22)	348 (26)	324 (19)	320 (24)	<.001
Antiarrhythmics	2301 (14)	136 (10)	186 (11)	144 (11)	<.001
Angiotensin antagonists	1268 (8)	135 (10)	222 (13)	127 (9)	<.001
Revascularization procedures	10 061 (63)	647 (49)	1127 (67)	859 (64)	<.001
Angiography	11 480 (72)	865 (65)	1260 (75)	988 (74)	<.001

Abbreviations: ACE, angiotensin-converting enzyme; COPD, chronic obstructive pulmonary disease.
*Data are from the northern California Kaiser Permanente Medical Care Program, 1995-2002.

mics. Asian women had the highest use of angiotensin antagonists and the lowest use of asthma/COPD agents. Hispanic women had the highest use of asthma/COPD agents. There were significant differences in revascularization procedures after index AMI across sex and racial/ethnic groups; they were more commonly performed in Asian men (67%) and least commonly performed in black women (41%). Documented angiography ranged from 75% in Asian men to 59% in black women.

During the 8-year follow-up, 4422 cohort members experienced a recurrent AMI (of those, 3682 were nonfatal and 740 fatal) and 6264 died (**Table 6**). Age-

Table 5. Clinical Characteristics of the Female Cohort by Race*

Characteristic	Racial Group, No. (%) (N = 10 061) White (n = 7929)	Black (n = 954)	Asian (n = 614)	Hispanic (n = 564)	*P* Value
Prevalent comorbidities					
Coronary heart disease	1447 (18)	239 (25)	104 (17)	157 (28)	<.001
Hypertension	4348 (55)	674 (71)	410 (67)	355 (63)	<.001
Diabetes	2323 (29)	404 (42)	289 (47)	307 (54)	<.001
Depression	2686 (34)	335 (35)	138 (22)	186 (33)	<.001
COPD	2607 (33)	314 (33)	188 (31)	179 (32)	.66
Asthma	1165 (15)	165 (17)	76 (12)	75 (13)	.03
Stroke	685 (9)	117 (12)	55 (9)	49 (9)	.003
Heart failure	623 (8)	141 (15)	54 (9)	54 (10)	<.001
Incident comorbidities					
Coronary heart disease	2861 (36)	382 (40)	232 (38)	227 (40)	.03
Hypertension	1731 (22)	171 (18)	115 (19)	126 (22)	.01
Diabetes	423 (5)	62 (6)	44 (7)	32 (6)	.15
Depression	1540 (19)	169 (18)	99 (16)	119 (21)	.08
COPD	978 (12)	108 (11)	54 (9)	62 (11)	.05
Asthma	470 (6)	64 (7)	32 (5)	42 (7)	.30
Stroke	523 (7)	69 (7)	38 (6)	29 (5)	.44
Heart failure	948 (12)	108 (11)	79 (13)	72 (13)	.76
Medication use at discharge or anytime thereafter					
β-Blockers	6427 (81)	799 (84)	523 (85)	476 (84)	.006
Nitrates and vasodilators	6426 (81)	814 (85)	498 (81)	465 (82)	.01
Agents to lower cholesterol levels	5689 (72)	657 (69)	472 (77)	439 (78)	<.001
ACE inhibitors	5266 (66)	701 (73)	417 (68)	397 (70)	<.001
Anticoagulants and antiplatelet agents	3804 (48)	403 (42)	265 (43)	258 (46)	.001
Calcium channel blockers	3266 (41)	486 (51)	296 (48)	267 (47)	<.001
Antidepressants	3549 (45)	375 (39)	185 (30)	253 (45)	<.001
Antiadrenergics	853 (11)	171 (18)	111 (18)	74 (13)	<.001
Antiarrhythmics	958 (12)	55 (6)	60 (10)	56 (10)	<.001
Angiotensin antagonists	1002 (13)	138 (14)	147 (24)	108 (19)	<.001
Revascularization procedures	3768 (48)	394 (41)	296 (48)	296 (52)	<.001
Angiography	4888 (62)	559 (59)	411 (67)	390 (69)	<.001

Abbreviations: ACE, angiotensin-converting enzyme; COPD, chronic obstructive pulmonary disease.
*Data are from the northern California Kaiser Permanente Medical Care Program, 1995-2002.

adjusted rates of AMI per 100 person-years of observation were higher in black women, black men, and Asian women; intermediate in Hispanic women; and lower in white men, Asian men, Hispanic men, and white women. In age-adjusted analyses relative to white men, black men (hazard ratio [HR], 1.44; 95% confidence interval [CI], 1.26-1.65), black women (HR, 1.47; 95% CI, 1.26-1.72), and Asian women (HR, 1.37; 95% CI, 1.13-1.65) were at significantly increased risk of AMI recurrence. However, multivariate adjustment for sociodemographic background, comorbidities, medication use, revascularization procedures, and angiography effectively removed the excess risk of AMI recurrence in these 3 groups. About half of the attenuation of risk occurred after adjustment for census sociodemographic background in model 2 and the other half after adjusting for clinical variables in model 3. Age-adjusted rates of all-cause mortality per 100 person-years of observation were higher in black men and black women and similar in the other sex and racial/ethnic groups (**Table 7**). Accordingly, in relation to white men, an increased age-adjusted risk of all-cause mortality was seen in black men (HR, 1.55; 95% CI, 1.37-1.75) and black women (HR, 1.45; 95% CI, 1.27-1.66), but this excess risk was greatly attenuated (and became statistically nonsignificant) in black men and was reversed in black women after multivariate adjustment. As in the case of AMI recurrence, the attenuation of the risk estimates was apparent in models 2 and 3 after adjusting for sociodemographic background and clinical variables, respectively. In the fully adjusted model (model 3), white and Hispanic women had a statistically significant lower risk of all-cause mortality compared with white men.

COMMENT

This prospective cohort study in a setting with equal and prepaid access to medical care shows that age-adjusted risk of AMI recurrence was significantly higher in black men, black women, and Asian women compared with white men and that age-adjusted risk of all-cause mortality after AMI was significantly higher in black men and women compared with white men. However, once a comprehensive set of covariables (including sociodemographic background, personal clinical history, and evidence-based medications) were accounted for, these sex and racial/ethnic disparities no longer existed. These re-

Table 6. Effect of Sex and Racial/Ethnic Groups With 3 Levels of Multivariate Adjustment on Nonfatal or Fatal AMI Recurrence*

Variable	Racial Group: White	Black	Asian	Hispanic
Men				
No. of events/persons	2226/15 905	231/1334	198/1686	193/1338
Crude, %	14.0	17.3	11.7	14.4
Person-years	46 353	3630	4932	4310
Age-adjusted rate/100 person-years	1.4 (1.1-1.7)	2.0 (1.6-2.6)	1.3 (1.1-1.7)	1.4 (1.1-1.8)
Level of adjustment, HR (95% CI)				
Model 1†	1.00	**1.44 (1.26-1.65)**	0.95 (0.82-1.10)	1.05 (0.91-1.22)
P value		<.001	.48	.52
Model 2‡	1.00	**1.24 (1.07-1.43)**	0.90 (0.78-1.05)	0.96 (0.83-1.11)
P value		.003	.19	.57
Model 3§	1.00	1.05 (0.91-1.22)	0.90 (0.77-1.04)	0.88 (0.76-1.02)
P value		.48	.16	.09
Women				
No. of events/persons	1191/7929	179/954	111/614	93/564
Crude, %	15.0	18.8	18.1	16.5
Person-years	21 041	2411	1490	1576
Age-adjusted rate/100 person-years	1.4 (1.1-1.7)	2.2 (1.7-2.8)	2.0 (1.6-2.7)	1.6 (1.2-2.1)
Level of adjustment, HR (95% CI)				
Model 1†	0.99 (0.92-1.06)	**1.47 (1.26-1.72)**	**1.37 (1.13-1.65)**	1.16 (0.94-1.42)
P value	.69	<.001	.002	.17
Model 2‡	0.97 (0.90-1.04)	**1.21 (1.03-1.42)**	**1.28 (1.05-1.55)**	1.05 (0.85-1.29)
P value	.42	.02	.01	.66
Model 3§	**0.90 (0.83-0.97)**	0.92 (0.78-1.08)	1.08 (0.88-1.31)	0.82 (0.66-1.01)
P value	.004	.28	.47	.06

Abbreviations: AMI, acute myocardial infarction; CI, confidence interval; HR, hazard ratio.

*Data are from northern California Kaiser Permanente Medical Care Program, 1995-2002. Comorbidities, medication use, angiography, and revascularization procedures were entered as time-dependent predictors. Census variables were entered as continuous variables. Boldfaced values indicate statistical significance at $P<.05$; 1.00, the referent.

†Adjusted for age and coverage type.

‡Adjusted for model 1 and sociodemographic background (median household income, percentage married, percentage completed college or higher, and percentage white).

§Adjusted for model 2, comorbidities, medication use, angiography, and revascularization procedures.

sults are consistent with the interpretation that minority groups in our population experience worse outcomes after AMI because of disadvantaged social milieu and higher prevalence of comorbid conditions and cardiovascular disease risk factors, and not because of biological differences between the sexes or race.

Our findings are in agreement with results from the Atherosclerosis Risk in Communities Study, in which black-white differences in mortality after AMI were explained by adjustment for vascular risk factors, socioeconomic position, and treatment,[28] and with earlier work in the KPMCP population demonstrating that after adjustments were made for risk profile and treatment modalities, women did not have a significantly increased risk for cardiovascular disease compared with men.[29]

Even in the age-adjusted analysis, the magnitude of the sex and racial/ethnic disparities in our cohort was much smaller than that previously reported in the literature.[1,17,28] This may reflect the lack of barriers to medical care and the effects of the Kaiser Permanente group model environment, which is anchored in sound evidence-based practice guidelines. The KPMCP in northern California has 4 centers of cardiovascular excellence (in San Francisco, San Jose, Oakland, and Sacramento), program-wide outpatient programs such as the Cholesterol Management Program and the MultiFit Cardiac Rehabilitation Program that reach all members regardless of sex and racial/ethnic background, and disease registries (such as diabetes and acute coronary syndromes) that facilitate prevention and health care effectiveness research.

Consistent with the Heart and Estrogen/Progestin Replacement Study,[17] black women in our sample had a higher prevalence of hypertension, diabetes, and hypercholesterolemia (and lower use of agents to lower cholesterol levels and higher use of angiotensin-converting enzyme inhibitors) compared with white women. An unexpected finding in the current analysis was the higher risk of AMI recurrence among Asian women (relative to white men), despite a somewhat favorable socioeconomic position. However, Asian women were found to have higher prevalences of hypertension and diabetes compared with white men.

The point has been made that racial differences in revascularization are in part responsible for mortality differences between black and white patients.[30] Schulman et al[31] documented, in a simulation study, that black women (compared with white men) were less often referred for cardiac catheterization despite having the same clinical presentation. In our cohort, we noted significant differences in revascularization procedures and angiography after AMI across sex and racial/ethnic groups such that black men were less likely than other men to

Table 7. Association With Sex and Racial/Ethnic Groups With 3 Levels of Multivariate Adjustment*

Variable	Racial Group			
	White	Black	Asian	Hispanic
		Men		
No. of events/persons	3074/15 905	299/1334	248/1686	239/1338
Crude rate, %	19.3	22.4	14.7	17.9
Person-years	50 513	4027	5236	4693
Age-adjusted rate/100 person-years	1.5 (1.2-1.9)	2.3 (1.9-2.9)	1.6 (1.3-2.0)	1.6 (1.3-2.0)
Covariates in the model, HR (95% CI)				
Model 1†	1.00	1.55 (1.37-1.75)	1.03 (0.90-1.17)	1.04 (0.91-1.19)
P value		<.001	.67	.53
Model 2‡	1.00	1.34 (1.18-1.52)	0.99 (0.87-1.13)	0.97 (0.85-1.11)
P value		<.001	.90	.62
Model 3§	1.00	1.02 (0.90-1.15)	1.09 (0.95-1.24)	0.90 (0.79-1.03)
P value		.81	.22	.13
		Women		
No. of events/persons	1916/7929	240/954	122/614	126/564
Crude rate, %	24.2	25.2	19.9	22.3
Person-years	23 037	2748	1664	1763
Age-adjusted rate/100 person-years	1.5 (1.2-1.9)	2.2 (1.8-2.8)	1.7 (1.3-2.2)	1.7 (1.3-2.2)
Covariates in the model, HR (95% CI)				
Model 1†	1.00 (0.94-1.06)	1.45 (1.27-1.66)	1.06 (0.88-1.27)	1.10 (0.92-1.32)
P value	.98	<.001	.53	.29
Model 2‡	0.99 (0.93-1.05)	1.22 (1.06-1.40)	1.01 (0.84-1.21)	1.02 (0.85-1.22)
P value	.63	.005	.93	.81
Model 3§	0.90 (0.85-0.96)	0.82 (0.71-0.94)	0.93 (0.78-1.13)	0.77 (0.64-0.92)
P value	<.001	.005	.47	.004

Abbreviations: CI, confidence interval; HR, hazard ratio.
*Data are from northern California Kaiser Permanente Medical Care Program, 1995-2002. Comorbidities, medication use, angiography, and revascularization procedures were entered as time-dependent predictors. Census variables were entered as continuous variables. The referents are 1.00.
†Adjusted for age and type of coverage.
‡Adjusted for model 1 and sociodemographic background (percentage of households below poverty level, percentage married, percentage working class, and percentage white).
§Adjusted for model 2, comorbidities, medication use, angiography, and revascularization procedures.

undergo revascularization procedures or angiography, and the same was true for black women. These findings are in agreement with those of a study in the Veterans Affairs System in which black patients received substantially fewer cardiac procedures after AMI than white patients, but, despite undergoing fewer interventional procedures, black patients had equivalent intermediate survival rates compared with white patients.[32] An excellent comprehensive review of this area also reached similar conclusions.[16] The lower rate of cardiac procedures among black patients may be the result of more diffuse atherosclerosis in black compared with white patients[33,34] rather than any overt prejudice on the part of physicians.

Our study has some notable limitations. First, we did not have information on potential mediating variables such as obesity, smoking, blood lipid levels, direct blood pressure measurements, thrombolysis at the index event, coronary anatomy, use of aspirin (because the pharmacy database did not capture over-the-counter medication), or time from chest pain presentation to hospital admission for AMI. However, we were able to adjust for treated dyslipidemia, antihypertension medication use as a surrogate for elevated blood pressure, and COPD and asthma as clinical surrogates of smoking. Second, although the authors did not specifically address sex and racial/ethnic groups, a previous Kaiser Permanente study[35] found that thrombolysis did not differ significantly by medical facilities with low or high rates of angiography. Third, we were not able to distinguish between ST-segment and non–ST-segment-elevation AMI. This distinction may be important, as demonstrated by recent data from the Euro Heart Survey of patients with acute coronary syndromes, in which female sex was a negative determinant of presenting with ST-segment elevation in patients younger than 65 years.[36] Fourth, we used census block groups' socioeconomic data as a proxy for individual-level socioeconomic standing, which may have introduced measurement error.[37,38] Finally, we did not segregate Asians into the different Asian subethnicities. The Asian population of the San Francisco Bay area, and thus KPMCP membership, is mainly Chinese, followed by Filipino and South Asian (Indian and Pakistani), with lesser representation of those with Japanese and Korean ancestry. Similarly, we did not consider the diverse Hispanic heritage, which in our geographic area consisted mostly of Mexican American and Central American ancestry, with a relatively lower proportion of persons with Cuban, Puerto Rican, or South American ancestry.

The strengths of the study include the large sample size derived from the general population (not from a few selected tertiary centers), the ability to remove the effect of access to health care (by virtue of being a KPMCP member), the excellent representation of racial/ethnic minority groups, the availability of high-quality clinical exposure variables and outcomes, and the socioeconomic indicators.

CONCLUSIONS

Our results are consistent with the hypothesis that racial/ethnic disparities after AMI are attributable to differences in socioeconomic standing, comorbidity burden, evidence-based therapies, and cardiac procedures. This conclusion has a number of possible explanations that our data could not address and that should be the topic of further research. For example, low socioeconomic standing may be associated with worse adherence to prescribed regimens of pharmacotherapy, exercise, diet, smoking cessation, or self-monitoring, with less involvement in medical decision making or with a longer time course from first symptom to hospital admission for AMI.

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