NIH Public Access
Author Manuscript
Ann Epidemiol. Author manuscript; available in PMC 2013 September 01.

Published in final edited form as:
Ann Epidemiol. 2012 September ; 22(9): 623–629. doi:10.1016/j.annepidem.2012.06.100.

Neighborhood Socioeconomic and Racial Disparities in Angiography and Coronary Revascularization: The ARIC Surveillance Study

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Abstract

Purpose—Disparities in the receipt of angiography and subsequent coronary revascularization have not been well-studied.

Methods—We estimated prevalence ratios and 95% confidence intervals (PR, 95% CI) for the association between neighborhood-level income (nINC) and receipt of angiography; and among those undergoing angiography, receipt of revascularization procedures, among 9,941 hospitalized myocardial infarction patients under epidemiologic surveillance by the Atherosclerosis Risk in Communities (ARIC) Study (1993–2002).

Results—In analyses by tertile of nINC controlling for age, study community, gender, and year, compared to whites from high nINC areas, blacks from low nINC (0.60, 0.54–0.66) and medium nINC (0.70, 0.60–0.78) areas, as well as whites from low nINC areas (0.83, 0.75–0.91) were less likely to receive angiography, while blacks from high nINC and whites from medium nINC areas were not. Associations were attenuated, but persisted, after controlling for event severity, medical history, receipt of Medicaid, and hospital type. Compared to high nINC whites, blacks were less likely, and whites were as likely, to undergo cardiac revascularization, given receipt of an angiogram.

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There are no financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years, and no other relationships or activities that could appear to have influenced the submitted work.

Conclusions—Black and lower nINC patients were less likely to undergo angiography than were whites and those from higher nINC areas. Among those receiving angiography, race, but not nINC, gradients persisted.

MeSH Key Words

social class; angiography; healthcare disparities

INTRODUCTION

Racial disparities in the receipt of diagnostic angiography [1–3] and coronary revascularization [3–12] among myocardial infarction (MI) patients are well-documented, with most studies reporting that whites are more likely to undergo these procedures than blacks. Gender differences in these procedures have been investigated, with reports of no differences[13] as well as a higher use of revascularization procedures among men. [7,13,14]

In contrast, the association of socioeconomic status (SES) with the receipt of diagnostic angiography and cardiac revascularization has been less well-studied among MI patients in the United States (US). A US-based study of Medicare beneficiaries reported that receipt of angiography and coronary revascularization procedures were less common among those residing in the lowest quintile of zip code-level SES, [14] while a review of hospital records of Pennsylvania residents reported modestly lower rates of revascularization among those living in lower SES areas, as defined by zip codes. [6] A Canadian study reported variations in rates of angiography but not coronary revascularization by census-based SES measures, [2] while a recent Australian study of acute coronary syndrome patients reported no differences by SES in the receipt of coronary artery bypass graft (CABG) and only modest variations in the receipt of coronary catheterization procedures, except in areas with a significant indigenous population, where socioeconomic disparities were evident. [15]

We investigated the association of neighborhood SES with variations in the receipt of angiography and coronary revascularization procedures among hospitalized MI patients in four administratively defined regions of the US. We further examined whether associations between neighborhood SES and receipt of coronary revascularization varied by race, gender and year of event.

METHODS

Overview

The Atherosclerosis Risk in Communities (ARIC) study's community-based surveillance of coronary heart disease (CHD) began in 1987 with methods previously described. [16,17] Potential MI events were identified via a retrospective review of hospital discharges for MI among white and black residents aged 35–74 years from four communities: Forsyth County, North Carolina (NC); the city of Jackson, Mississippi (MS); northwest suburbs of Minneapolis, Minnesota (MN); and Washington County, Maryland (MD). The NC and MS areas included substantial numbers of both black and white participants, while the MD and MN communities were predominantly white.

MI Case Ascertainment and Receipt of Angiography and Coronary Revascularization

Hospital discharge diagnosis codes meeting age and residential inclusion criteria were obtained annually from the participating hospitals and a stratified random sampling was applied [17] to select potential events for full record abstraction and evaluation. ARIC study personnel reviewed records for presenting symptoms, medical history, and pertinent laboratory values and electrocardiograms (ECG). Events were classified as definite, probable, suspect or no MI by computer algorithm, with selected cases reviewed for final classification. Only events classified as definite or probable MI were included in these analyses. We defined an MI as incident if there was no evidence of a prior MI in the medical record, and classified all other MIs as repeat events.

Our primary outcome was the receipt of angiography and any revascularization procedure, as indicated in the medical record. In secondary analyses we considered each type of revascularization procedure (angioplasty, stent, and CABG) separately. We did not include thrombolytic therapy (e.g., tissue plasminogen activator [tPA] reperfusion, intervenous streptokinase), as its receipt is not dependent upon angiography.

Neighborhood SES

Patient addresses were abstracted from the medical record and geocoded by a commercial vendor previously chosen for coding accuracy. [18] Exact address matches were obtained for 93% of addresses and an additional 2% matched to the census tract (CT). We linked each event with 2000 US Bureau of the Census data. We used CT median household income (nINC) to represent neighborhood socioeconomic conditions, as nINC is correlated with poverty and has gradients with health outcomes comparable to those seen with more complex index measures in this [19] and other studies. [20] nINC was further classified into tertiles across all study communities (high: >$50,032; medium: $33,533–50,032; low: < $33,533).

Covariates and Effect Modifiers

We included age, race, study community, gender, year of the MI, whether the admitting hospital was classified as teaching or non-teaching (based on whether or not the facility had an internal medicine residency program), and prehospital delay (time elapsed between symptom onset and hospital arrival) as covariates. For most analyses, we divided prehospital delay into the following categories: <2 hour (hr), 2–12 hr, >12 hr-≤3 days. We classified health insurance status into two categories: Medicaid recipient vs. not. This decision was made because of the strong association of receipt of Medicaid with poverty [21,22] and because in our work to date, receipt of Medicaid has been consistently associated with cardiovascular disease (CVD) outcomes. [23]

Measures of MI severity and other characteristics included the presence of cardiac pain, shock, cardiac biomarker levels and ECG data. Cardiac pain on admission was dichotomized as presence or absence of pain occurring anywhere in the anterior chest, left arm, or jaw. Evidence of cardiogenic shock was abstracted from medical records and classified as low, medium and high. Cardiac biomarker levels were classified as 'abnormal', 'equivocal', 'incomplete' or 'normal'. ECGs were recorded and classified as 'evolving diagnostic', 'diagnostic', 'evolving ST-T', 'equivocal' or 'absent', 'uncodable' or 'other' using a standardized algorithm. As an alternative way of evaluating the potential contribution of event severity to the nINC-procedure associations, we conducted all analyses with and without MI patients who died within 24 hrs.

We ascertained presence of related conditions (diabetes, angina, CABG, hypertension, stroke, or heart failure, smoking, chronic obstructive lung disease [COPD]) as indicated in the medical record, whether past history or diagnosed at the time of the MI.

Exclusion Criteria

From 1987 through 2002, an estimated 11,656 definite or probable MI events occurred among persons aged 35–74 years in the four communities. We included MIs occurring in

1993 or after (N=10,461), as address data were not abstracted prior to this time. We excluded 135 MIs among patients who were not black or white, 145 MIs among blacks living in MN or MD, and 240 missing data on receipt of cardiac procedures. After these exclusions, 9,941 (14,063 weighted, according to previously described sampling criteria) MI events were available for analysis.

Analyses of receipt of cardiac revascularization was limited to 7,375 (9,315 weighted) patients undergoing angiography. We restricted analyses for receipt of stent to year 1998 and later, when these data became available.

Analyses

We calculated weighted, age-adjusted and race-specific (MS and NC study communities only) proportions of patients receiving angiography overall and by tertile of nINC. Among the subset of patients undergoing angiography, we also calculated proportions undergoing any revascularization procedure as well as by type of revascularization procedure (angioplasty, stent, CABG).

Because angiography is a common diagnostic procedure among acute MI patients, we implemented Poisson regression using generalized estimation equations and a robust variance estimator to estimate prevalence ratios (PR) and 95% confidence intervals (CI). All analyses were weighted to account for the underlying sampling probabilities. We assessed effect modification ($p < 0.05$) by age, gender, and year of MI. In the two study communities with a substantial number of black patients (NC and MS), we created nINC*race strata. Within these strata, we tested effect modification by age, study community, gender and year of MI. In analyses of whites from all four communities, we considered age, study community, gender and year of MI as effect modifiers.

Initially, we stratified patients by whether they experienced an incident or a repeat MI. While the proportion of patients undergoing angiography tended to be higher among incident than repeat MI cases, the associations by nINC and by race were essentially the same (data not shown), and we combined these groups. The modeling strategy accounted for the clustering of patients within CTs as well as repeat events among patients.

RESULTS

Table 1 presents characteristics of the MI patients overall and among the subset of those receiving angiography and coronary revascularization. Patients averaged 61 years of age. Thirty-four percent were women and 21 percent were black. The average nINC was $42,404 and 12% were Medicaid recipients. The distribution of CT median household income varied markedly among blacks and whites. Almost 80% of black MI patients lived in low nINC areas, whereas fewer than 20% of whites lived in low nINC areas. The prevalence of current smoking among the MI patients was high, as were comorbidities and prior CVD.

Overall, 66% of MI patients received angiography. Of these, 73% subsequently had a coronary revascularization procedure (48% of all MI patients). Angiography and revascularization recipients tended to live in more affluent neighborhoods and were less likely to be black, female and recipients of Medicaid than were all MI patients. While those undergoing angiography and revascularization were more likely to have had an incident than a recurrent MI, they were less likely to have a history of CVD risk factors, COPD, stroke, angina or coronary insufficiency, and heart failure than were all MI patients.

Figure 1 presents the age- and gender-adjusted proportion of MI patients undergoing angiography (shaded area), and among those undergoing angiography, the proportion receiving any and each coronary revascularization procedure by tertile of nINC. Three graphs are included: two for MS and NC [Figure 1a (blacks) and Figure 1b (whites)] and one for MD and MN [Figure 1c (whites)]. Black MI patients in MS and NC were consistently less likely to undergo angiography than were white patients in the same and other communities, and within race groups, those in the low nINC areas were less likely to receive angiography compared to those in the medium and high nINC areas. Black MI patients were consistently less likely to undergo any and each coronary revascularization procedure than were whites in the same and other study communities. Further, in both race groups, those in low nINC areas tended to undergo coronary revascularization less than those from more affluent areas. However, clear nINC gradients were not apparent and CIs tended to overlap.

Table 2 presents PR estimates and 95% CIs for receipt of angiography and, among those undergoing angiography, receipt of any revascularization procedure for race-nINC groups in the MS and NC communities, with high nINC whites serving as the referent. In initial analyses, there was no significant effect modification by gender or year of MI; thus, these variables were included as covariates in subsequent models. In models adjusting for age, study community, gender, and year of MI (Model 1), compared to whites from high nINC areas, blacks from low nINC (0.60, 0.54–0.66) and medium nINC (0.70, 0.60–0.78) areas, as well as whites from low nINC areas (0.83, 0.75–0.91) were less likely to receive angiography, while blacks from high nINC (0.90, 0.73–1.09) and whites from medium nINC (0.97, 0.91–1.04) were not. Associations among low and medium nINC blacks and low nINC whites were attenuated, but persisted after controlling for other covariates, including receipt of Medicaid, comorbidities and indicators of MI severity (Model 2).

Among patients undergoing angiography, in models adjusting for age, study community, gender, and year of MI (Model 1), compared to high nINC whites, blacks at all nINC levels were less likely to undergo coronary revascularization. Differences were largest for blacks living in low nINC areas (0.69) and smallest (0.84) among those living in high nINC areas. After adjustment for additional covariates (Model 2), associations were attenuated and CIs for estimates for high nINC blacks included the null values. Further, clear nINC gradients were no longer evident. In both minimally and fully adjusted models, whites in low and medium nINC areas were as likely to undergo revascularization as were whites from high nINC areas. Analyses were repeated excluding MI patients dying within the first 24 hrs, and results were essentially unchanged. We re-ran analyses using race-specific nINC cutpoints, creating similarly sized nINC groups within race strata, and the results were similar to those presented above using community-wide nINC cut points (data not shown).

We ran additional models to examine the nINC- angiography and nINC-revascularization association for all white MI patients across the four study communities (Table 3). In models adjusting for age, study community, gender, and year of MI (Model 1), those living in low nINC neighborhoods were less likely to receive an angiogram than were those living in high nINC neighborhoods (0.83, 0.77–0.89) while those living in medium nINC areas were not (0.97, 0.93–1.02). The association among those living in low nINC areas was attenuated but persisted after controlling for additional covariates (Model 2). In contrast, among those undergoing angiography, there was no variation in the receipt of revascularization across nINC strata.

DISCUSSION

In the areas under epidemiologic surveillance by ARIC, MI patients from lower nINC areas were less likely to undergo angiography than were those from higher nINC neighborhoods. After controlling for MI severity and CVD risk factors, this graded association, while attenuated, persisted among blacks. In contrast, among whites, only a modest association persisted, and it was limited to the low nINC group. Among those undergoing angiography, after taking into account MI severity and CVD risk factors, there was no variation in receipt of revascularization by nINC. However, black MI patients of all nINC strata were modestly less likely to undergo revascularization than were whites in the same study areas.

The paucity of socioeconomic information in vital records used for disease surveillance systems in the US has been previously discussed, [24] as has the potential for overcoming this deficit by including neighborhood socioeconomic data. [20,25] We demonstrate that this approach can also be successfully used with a community-based surveillance system relying on hospital records. [23,26] Studies generally report only moderate correlations between individual and contextual SES measures, [25,27] and while studies that consider the joint "effects" of neighborhood and individual SES on health outcomes often report an attenuation of neighborhood effects, most report that significant neighborhood effects persist. [28–31] Given the lack of individual SES data in the hospital records used to identify our surveillance cases, it is challenging to address this is issue in our work. However, we included receipt of Medicaid as an individual-level covariate since Medicaid eligibility is most often based on poverty status. [21,22] In our multivariable analyses, those receiving Medicaid were modestly less likely to undergo angiography [(0.85, 0.76–0.93 in models including blacks and whites in MS and NC) and (0.88, 0.81–0.96 for whites in all four study communities)] and any revascularization [(0.88, 0.80–0.98 in models including blacks and whites in MS and NC) and (0.92, 0.84–1.00 for whites in all four study communities)] than were non-recipients. Further, the inclusion of Medicaid in models presented in Table 2 did not substantially impact the nINC-angiography or the nINC-revascularization associations.

Mechanisms by which place of residence influences cardiovascular health include access to healthy food, [32] the built environment, [33] exposure to psychological stress [34] and a higher prevalence of unhealthy behaviors such as smoking [35] and physical inactivity. [35] While these factors do not directly impact the type of care that one receives when hospitalized for an MI, they may indirectly impact diagnostic and treatment options during an MI hospitalization via their contribution to patients' health status at the time of hospitalization.

We did not find support in our data for an effect of receipt of care at different types of hospitals among patients by race or nINC, ascontrolling for type of hospital (teaching vs. non-teaching) did not change our results. We additionally examined within-hospital variation in the receipt of angiography by race and nINC by restricting our analysis to seven hospitals in MS and NC which had more than 100 MI cases in each race stratum (only one hospital had fewer cases). White patients were 1.1 to 2.5 times as likely to undergo angiography as compared to black patients at the same facility. The number of events precluded further examination stratified by nINC within race groups. Nonetheless, black MI patients from low nINC neighborhoods were consistently less likely to undergo coronary revascularization than were those in high nINC neighborhoods (data not shown). Similar but weaker nINC disparities were evident among whites in these hospitals.

Although the two ARIC surveillance areas with a substantial black population are in the southern US and are thus unlikely to be representative of blacks in other regions of the country, the magnitude of variation in nINC by race seen in the ARIC surveillance communities was similar to recent nationwide figures. [36] Since there were relatively small numbers of blacks living in higher income neighborhoods, our estimates for high nINC blacks were less precise. It is reassuring that when we repeated our analyses using race-specific nINC cut points, patterns persisted.

The lack of information on whether angiography or coronary procedures were offered or refused is a limitation of our study. While it is commonly believed that racial disparities in the receipt of cardiac care are partly due to higher refusal rates among black patients, empirical data assessing variations in refusal rates by race are not consistent. While some reports suggest higher catheterization refusal rates among blacks [12] other studies suggest that differential rates of refusal of catheterization or interventional cardiac procedures do not likely explain racial disparities. [10,37–39] Further, a recent study reporting racial disparities in refusal rates found that once physician recommendations were taken into account, disparities by race were no longer evident. [40] To date, issues relating to variations in patient refusal to undergo revascularization as well as physicians' recommendations by SES have not been addressed systematically. [9]

Although some literature suggests that race/ethnicity does not independently influence care, [41] and that racial disparities in health care primarily reflect socioeconomic disparities [37,42,43] or variations in the social context, [1] our results do not support this view. Within each nINC strata, black MI patients were less likely to undergo angiography than were their white counterparts. Similarly, among those undergoing angiography, after taking into account comorbidities and MI characteristics, black patients in all nINC groups (with no evidence of an nINC gradient) were less likely to undergo cardiac revascularization than whites in all nINC groups. The work reported here, as well as a larger body of work addressing racial disparities, [44] indicate that disparities in cardiac care are not fully explained by factors such as health insurance or disease severity. Thus, as recently recommended, [9] educational interventions aimed at increasing the awareness levels of both patients and physicians should be explored as potential strategies for addressing these persistent disparities in care.

Acknowledgments

This research was supported by contract 1R01HL080287 (Dr. Rose, PI) from the National Heart, Lung, and Blood Institute (NHLBI) andwas also funded in part by National Institutes of Health, NHLBI, and National Research Service Award training grant 5-T32-HL007055-30 (Dr. Foraker). The ARIC study is carried out as a collaborative study supported by NHLBI contracts N01-HC-55015, N01-HC-55016, N01-HC-55018, N01-HC-55019, N01-HC-55020, N01-HC-55021, andN01-HC-55022.

This study was conducted with the approval of the corresponding study sites of the Atherosclerosis Risk in Communities (ARIC) study.

We thank the staff of the ARIC study for their important contributions.

ABBREVIATIONS

ARIC	Atherosclerosis Risk in Communities
CABG	coronary artery bypass graft
CHD	coronary heart disease
CI	confidence interval
COPD	chronic obstructive pulmonary disease
CT	census tract
CVD	cardiovascular disease
ECG	electrocardiogram
hr	hour

MD	Maryland
MI	myocardial infarction
MN	Minnesota
MS	Mississippi
NC	North Carolina
nINC	neighborhood income; median household income
PR	prevalence ratio
SES	socioeconomic status
tPA	tissue plasminogen activator
US	United States

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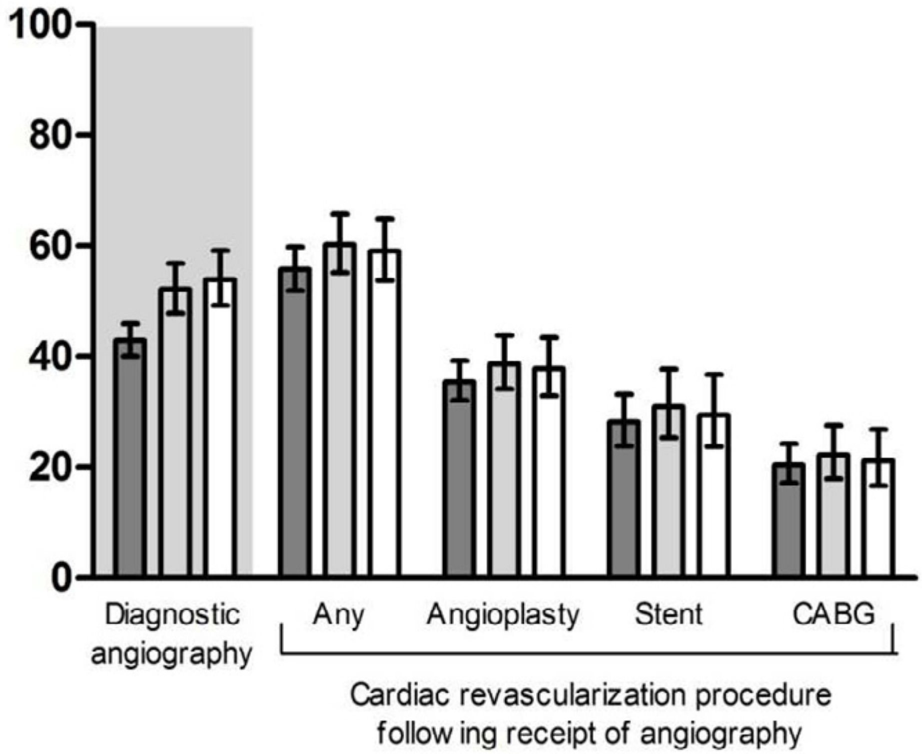
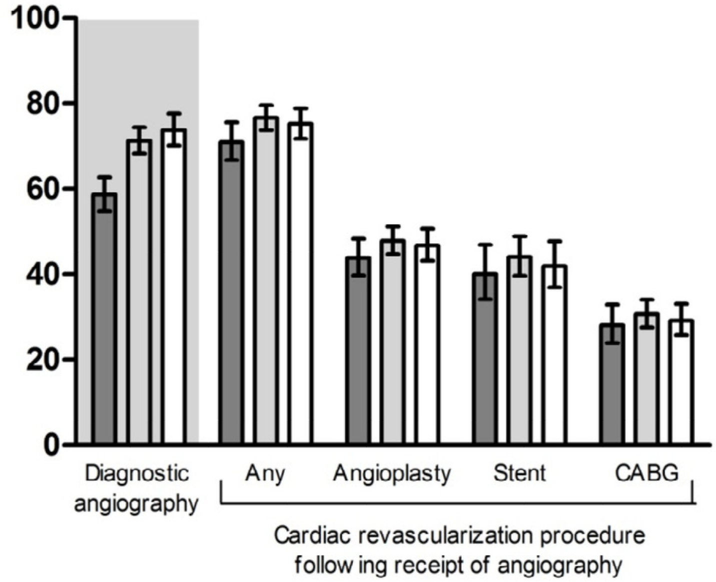
(a) MS and NC, Blacks



(b) MS and NC, Whites



(c) MD and MN, Whites

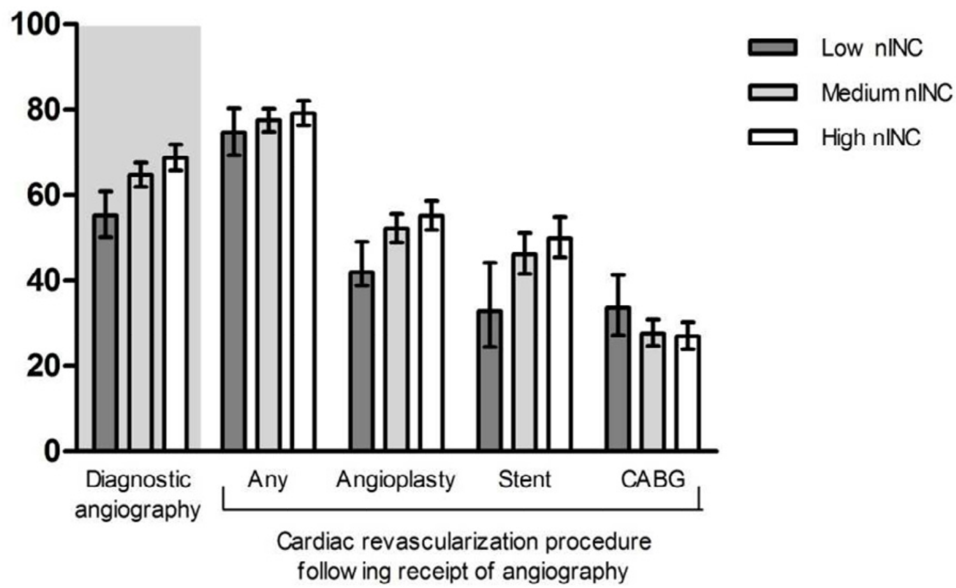


Figure 1.

Age-adjusted proportions (and 95% CI) of receipt of angiography, any and specific coronary revascularization procedures* by race and nINC, ARIC community surveillance MI patients (1993–2002)

- **a.** MS and NC, Blacks
- **b.** MS and NC, Whites
- **c.** MD and MN, Whites

*Stent analyses include patients only for the years 1998 and after.

Table 1

Sociodemographic characteristics (%), ARIC surveillance MI patients (1993–2002)

Characteristic	Overall	Angiography Recipients	Revascularization Recipients
	n=14,063	n=9,315	n=6,792
	100%	66%	48%
Median Household Income, Mean (US dollars)	$42,404	$44,420	$45,386
Black			
Low nINC	77.4	73.6	73. 2
Medium nINC	16.6	19.3	19.0
High nINC	6.0	7.1	7.8
White			
Low nINC	16.8	14.9	13.9
Medium nINC	47.0	47.1	47.7
High nINC	36.2	38.0	38.4
Age, Mean (yrs)	60.7	59.6	59.9
Incident Event (vs. Repeat Event)	67.0	75.0	77.1
Black	21.2	16.0	12.4
Female	34.3	32.0	30.2
Field Center			
Forsyth County, NC	36.5	38.4	39.0
Jackson, MS	21.5	18.0	14.7
Minneapolis, MN	20.0	21.8	23.5
Washington County, MD	22.0	21.8	22.8
Medicaid Recipient	12.2	8.1	6.6
Teaching Hospital (vs. Non-Teaching)	41.7	42.8	43.9
Prehospital Delay Time			
< 2 hours	31.4	32.9	32.5
2–<12 hours	34.5	33.7	32.3
> 12 hours	34.1	33.4	35.2
Presence of Chest Pain Smoking Status	85.4	94.5	95.1
Current	38.9	41.1	41.1
Past	31.8	30.2	31.3
Never	28.3	28.7	27.6
Clinical History			
Diabetes	32.9	27.8	26.7
Angina or Coronary	36.8	31.1	29.7
Insufficiency	62.5	58.1	56.2
Hypertension	9.4	6.5	6.0
Stroke	14.5	10.9	9.0
CABG			
COPD Present	17.6	13.3	13.0

Characteristic	Overall n=14,063 100%	Angiography Recipients n=9,315 66%	Revascularization Recipients n=6,792 48%
Heart Failure/Pulmonary Edema Present	35.9	26.9	25.5

Table 2

Prevalence ratios (PR) and 95% confidence intervals (95% CI) for receipt of angiography and receipt of any revascularization procedure, given prior receipt of angiography, ARIC community surveillance (1993–2002): Whites and blacks in MS and NC

	Angiography		Revascularization Procedure	
	Model 1*	**Model 2†**	**Model 1***	**Model 2†**
Blacks				
Low nINC	0.60 (0.54, 0.66)	0.73 (0.68, 0.81)	0.69 (0.61, 0.78)	0.87 (0.79, 0.95)
Medium nINC	0.70 (0.60, 0.81)	0.83 (0.73, 0.94)	0.75 (0.67, 0.85)	0.80 (0.68, 0.94)
High nINC	0.90 (0.73, 1.09)	0.94 (0.78, 1.14)	0.84 (0.77, 0.93)	0.86 (0.70, 1.06)
Whites				
Low nINC	0.83 (0.75, 0.91)	0.93 (0.86, 1.00)	0.95, 0.89, 1.01)	1.04 (0.96, 1.13)
Medium nINC	0.97 (0.91, 1.04)	1.01 (0.96, 1.06)	1.03 (0.98, 1.09)	1.05 (0.99, 1.11)
High nINC	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)

*Model 1: Race/nINC (white/high nINC as referent category), age, gender, study community, and year of MI

†Model 2: Model 1 plus hospital type (teaching vs. non-teaching); prehospital delay time; presence of pain; shock, enzyme and ECG data; co-occurring COPD; smoking status; history of diabetes, angina, CABG, hypertension, stroke and heart failure/pulmonary edema; Medicaid status

Table 3

Prevalence ratios (PR) and 95% confidence intervals (95% CI) for receipt of angiography and receipt of any revascularization procedure given prior receipt of angiography, ARIC community surveillance (1993–2002): Whites from all surveillance sites (MS, NC, MN and MD)

	Angiography		Revascularization Procedure	
	Model 1*	**Model 2†**	**Model 1***	**Model 2†**
Low nINC	0.83 (0.77, 0.89)	0.92 (0.87, 0.98)	0.98 (0.92, 1.04)	0.99 (0.94, 1.05)
Medium nINC	0.97 (0.93, 1.02)	1.02 (0.98, 1.05)	1.01 (0.98, 1.05)	1.01 (0.98, 1.05)
High nINC	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)

*Model 1: nINC, age, gender, study community, and year of MI

†Model 2: Model 1 plus hospital type (teaching vs. non-teaching); prehospital delay time; presence of pain; shock, enzyme and ECG data; smoking status; co-occurring COPD; history of diabetes, angina, CABG, hypertension, stroke, and heart failure/pulmonary edema; Medicaid status