Title

Association between race/ethnicity and income on the likelihood of coronary revascularization among postmenopausal women with acute myocardial infarction: Women's health initiative study

Authors

Tertulien, Tarryn
Roberts, Mary B
Eaton, Charles B
et al.

Publication Date

2022-04-01

DOI

10.1016/j.ahj.2021.12.013

Peer reviewed

HHS Public Access

Author manuscript

Am Heart J. Author manuscript; available in PMC 2023 April 01.

Published in final edited form as:

Am Heart J. 2022 April ; 246: 82–92. doi:10.1016/j.ahj.2021.12.013.

Association Between Race/Ethnicity and Income on the Likelihood of Coronary Revascularization Among Postmenopausal Women with Acute Myocardial Infarction: Women's Health Initiative Study

Tarryn Tertulien, MD, MSc[1], **Mary B. Roberts, MS**[2], **Charles B. Eaton, MD, MS**[3], **Crystal W. Cene, MD, MPH**[4], **Giselle Corbie-Smith, MD, MSc**[5], **JoAnn E. Manson, MD, DrPH**[6], **Matthew Allison, MD, MPH**[7], **Rami Nassir, PhD**[8], **Khadijah Breathett, MD, MS**[9]

[1]Department of Medicine, University of Pittsburgh Medical Center, Pittsburgh, PA

[2]Brown University Center for Primary Care & Prevention, Care New England Medical Group/ Primary Care & Specialty Services, Pawtucket, RI

[3]Department of Family Medicine, Alpert Medical School of Brown University, Providence, RI, Department of Epidemiology, Brown University School of Public Health, Providence, RI

[4]Department of Medicine, University of North Carolina at Chapel Hill, NC

[5]Department of Social Medicine and Medicine, University of North Carolina Chapel Hill, NC

[6]Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA

[7]Department of Family Medicine, University of California San Diego, CA

[8]Department of Pathology, School of Medicine, Umm Al-Qura University, Saudi Arabia

[9]Division of Cardiology, Advanced Heart Failure & Transplant, University of Arizona, Tucson, AZ

Abstract

*Corresponding Author: Khadijah Breathett, MD, MS, University of Arizona, Sarver Heart Center, 1501 North Campbell Avenue, PO Box 245046; Tucson, AZ 85724. kbreathett@shc.arizona.edu.

A Short List of WHI Investigators

Program Office: Jacques Rossouw, Shari Ludlam, Dale Burwen, Joan McGowan, Leslie Ford, and Nancy Geller (National Heart, Lung, and Blood Institute, Bethesda, Maryland).

Clinical Coordinating Center: Garnet Anderson, Ross Prentice, Andrea LaCroix, and Charles Kooperberg (Fred Hutchinson Cancer Research Center, Seattle, WA).

Investigators and Academic Centers: JoAnn E. Manson (Brigham and Women's Hospital, Harvard Medical School, Boston, MA); Barbara V. Howard (MedStar Health Research Institute/Howard University, Washington, DC); Marcia L. Stefanick (Stanford Prevention Research Center, Stanford, CA); Rebecca Jackson (The Ohio State University, Columbus, OH); Cynthia A. Thomson (University of Arizona, Tucson/Phoenix, AZ); Jean Wactawski-Wende (University at Buffalo, Buffalo, NY); Marian Limacher (University of Florida, Gainesville/Jacksonville, FL); Robert Wallace (University of Iowa, Iowa City/Davenport, IA); Lewis Kuller (University of Pittsburgh, Pittsburgh, PA); Sally Shumaker (Wake Forest University School of Medicine, Winston-Salem, NC).

WHI Memory Study: Sally Shumaker (Wake Forest University School of Medicine, Winston-Salem, NC).

Conflict of Interest Disclosures

None reported

Background——Historically, race, income, and gender were associated with likelihood of receipt of coronary revascularization for acute myocardial infarction (AMI). Given public health initiatives such as Healthy People 2010, it is unclear whether race and income remain associated with the likelihood of coronary revascularization among women with AMI.

Methods——Using the Women's Health Initiative Study, hazards ratio (HR) of revascularization for AMI was compared for Black and Hispanic women versus White women and among women with annual income <$20,000/year versus ≥$20,000/year over median 9.5 years follow-up(1993–2019). Proportional hazards models were adjusted for demographics, comorbidities, and AMI type. Results were stratified by revascularization type: percutaneous coronary intervention (PCI) and coronary artery bypass grafting(CABG). Trends by race and income were compared pre- and post-2010 using time-varying analysis.

Results——Among 5,284 individuals with AMI (9.5% Black, 2.8% Hispanic, and 87.7% White; 23.2% <$20,000/year), Black race was associated with lower likelihood of receiving revascularization for AMI compared to White race in fully adjusted analyses [HR:0.79(95% Confidence Interval:[CI]0.66,0.95)]. When further stratified by type of revascularization, Black race was associated with lower likelihood of PCI for AMI compared to White race [HR:0.72(95% CI:0.59,0.90)] but not for CABG [HR:0.97(95%CI:0.72,1.32)]. Income was associated with lower likelihood of revascularization [HR:0.90(95%CI:0.82,0.99)] for AMI. No differences were observed for other racial/ethnic groups. Time periods (pre/post-2010) were not associated with change in revascularization rates.

Conclusion——Black race and income remain associated with lower likelihood of revascularization among patients presenting with AMI. There is a substantial need to disrupt the mechanisms contributing to race, sex, and income disparities in AMI management.

Keywords

acute myocardial infarction; PCI; CABG; coronary revascularization; race/ethnicity; income

INTRODUCTION

Social determinants of health are pertinent to acute myocardial infarction (AMI), given their relationship to accessing healthcare and attaining good health outcomes.[1–3] Intersections of race, gender, and income disparities have been well documented in receipt of cardiovascular procedures.[4–8] These studies have found that Black individuals are less likely than White individuals to receive various invasive cardiac procedures such as percutaneous coronary intervention (PCI) and coronary artery bypass surgery (CABG).[7] Likewise, gender differences were also noted in the literature. Prior research has shown that women with acute myocardial infarction (AMI) experienced more reperfusion therapy delays than men.[9–11] Similarly, individuals with lower income have a lower probability of undergoing revascularization procedures.[12] Receiving timely and appropriate therapy when presenting with AMI has a beneficial impact on health outcomes. Given the disparities in healthcare delivery and access.[13,14] national initiatives[6,15] such as Health People 2010 have been implemented to ameliorate such inequalities by setting goals to improve access to revascularization therapies for AMI.[16,17]

While reducing racial and socioeconomic disparities has been a national priority, relatively few longitudinal studies have assessed changes in receipt of AMI therapy. Previous reports suggest that racial disparities persist in coronary revascularization timing, rates, and outcomes.[18–20] A recent comprehensive meta-analysis identified low income as having a predominantly adverse association with myocardial infarction risk factors, incidence, and survival.[21] Studies analyzing the previously noted disparity trends among patients with AMI in the last decade (2010–2020) are limited.

Addressing revascularization for an indication, AMI, that is generally appropriate is essential to help uncover the true racial, ethnic, and income disparities. Large national studies suggest that, among non-acute settings, PCI is inappropriate in 12% of the cases, and the appropriateness is uncertain in 38% of cases.[22] Therefore, racial/ethnic- and income-based differences in the receipt of coronary revascularization for treatment of AMI were examined using the Women's Health Initiative study (WHI), the largest longitudinal study of postmenopausal women. We hypothesized that Black women, Hispanic women, and women with <$20,000 annual income would receive less revascularization than White women and women with ≥$20,000 when presenting with AMI. Secondarily, we hypothesized that trends in revascularization have improved in the last decade compared to the preceding decade.

METHODS

Data Source

The WHI is a national health study sponsored by the National Institutes of Health (NIH), National Heart, Lung, and Blood Institute (NHLBI). It is a study of United States postmenopausal women followed for greater than 20 years to evaluate cardiovascular disease (including coronary heart disease, congestive heart failure, stroke, angina, peripheral vascular disease, carotid artery disease, coronary revascularization), cancer, and osteoporosis.[23] The original study is one of the largest women-only population studies, including 161,808 postmenopausal women aged 50–79 years who enrolled in one or more of its clinical trials (CT) or the observational studies (OS) between 1993 and 1998.[23,24] The study includes self-reported medical information collected through interviews and surveys by WHI personnel and the review of medical records for outcome determination.[25,26]

Study Cohort

A cohort of 5,284 postmenopausal women from WHI with AMI was ascertained from baseline enrollment (1993–1998) through March 2019. Participants with missing exposure variables were excluded (Figure 1). Exclusion criteria included missing race, ethnicity, race classification as 'other,' missing or unknown income, self-reported MI at enrollment, and inability to classify MI type. Of note, these conditions were not mutually exclusive. The study was approved by the human subjects' review committee at each WHI participation institution, and all participants provided informed consent.

Covariates

Race and ethnicity were self-identified as non-Hispanic Black, Hispanic, and non-Hispanic White. Income was categorized into two groups: <$20,000 and ≥$20,000, since 2020 federal poverty levels range between $17,240–26,200 for a household of two to four individuals.[27]

Additional covariates include AMI type, non-ST elevation MI (NSTEMI), and ST-elevation MI (STEMI). Participants were followed until the development of AMI. All AMI outcomes were identified annually by medical record review of all self-reported hospitalizations and adjudicated by trained physician adjudicators. In the WHI, diagnoses of AMI and treatment with coronary revascularization were established by physician adjudicators based on the review of medical records using standardized forms and definitions. Three factors were used to classify AMI: chest pain, diagnostic or suggestive ECG changes, and abnormal cardiac markers.[26,28] AMI was adjudicated for CT and OS trials through Extension 1 (2005–2010). In Extension 2 (2010–2015), AMI was only adjudicated for the Medical Record Cohort (MRC).

Outcome of Interest

The primary outcome for this study was receipt of coronary revascularization. The type of revascularization for participants with AMI (STEMI, NSTEMI) included PCI and CABG. PCI was adjudicated only during the index hospitalization for AMI. CABG was adjudicated for all hospitalized indications, which primarily included AMI but also coronary heart disease, since CABG for the treatment of AMI can be performed at a hospitalization encounter separate from AMI hospitalization. Thrombolysis was excluded as a means of revascularization due to decreased use in AMI.

Statistical Analysis

Data from the WHI's OS and CT were used for this analysis. Participants with missing exposure or outcome data were excluded. For the cohort of 5,284 eligible WHI participants, baseline characteristics were summarized using means and standard deviations or frequencies and percentages. Descriptive statistics by race/ethnicity and by income level were used to characterize the population that had AMI.

Using Cox proportional hazards models, the unadjusted, age-adjusted, and fully adjusted hazards ratios (HR) were examined by race/ethnicity and annual income to evaluate potential disparities in coronary revascularization receipt among patients with AMI. Due to differences in tracking protocol, follow-up time for participants in the self-report cohort of extension 2 was censored at the end of extension 1. Cox models were stratified by membership in the self-report cohort and by hormone therapy arm. Model 1 was adjusted for age. Model 2 was adjusted for age, education, physical activity, smoking status, diabetes, hypertension, hyperlipidemia, heart failure, obesity, AMI type, insurance type, and region. Model 3 was adjusted for model 2 components plus either race/ethnicity or income for respective output for income or race/ethnicity (Supplemental Tables 1A, 1B, 1C). All models were tested for violations of the proportional hazards' assumption.

We examined the cumulative incidence of coronary revascularization from 2005 through 2019. Annual incidence rates were calculated as a percent of events occurring each year of the WHI Extensions. Cumulative incidence rates, expressed per 1000 person-years of follow-up, were calculated by summing the annual person-year incidence rates for all years up to and including the year plotted on the graph. The annualized trend graphs of race/ethnicity and income were generated by taking the accumulated number of cases by year and dividing by the accumulated number of person-years which was then standardized to reflect annual cumulative rates per 1000 person-years of follow-up.

In a secondary analysis, the data were categorized into two time periods, before (1993–2010) and after 2010 (2011 −2019), to examine changes in the incidence of revascularization for AMI by race/ethnicity and annual income. To compare results between the two periods, follow-up time and age were adjusted in the latter decade (post-2010 period) in addition to analyses conducted for Model 3 above. All analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC). A two-sided p-value ≤ 0.05 was considered significant.

RESULTS

Cohort Characteristics

Among WHI participants, 5,284 participants (age 66.3±6.8 years; 502 Black race, 147 Hispanic ethnicity, and 4,635 White race) developed AMI over the span of this analysis (Table 1). The majority of participants with AMI had an income greater than $20,000 (76.8%), public/no insurance (58.5%), hypertension (50.3%), some college education or higher (72.4%). Compared to women with ≥ $20,000 per year, women with <$20,000 income were more likely to have public/no insurance (73.9% vs. 53.9%) and less likely to be college graduates (13.4% vs. 38.0%). There was no racial difference in the OS and CT participants in the WHI cohort. A higher proportion of participants with an income ≥$20,000 were in the OS than CT cohort. Black (71.5%) and Hispanic participants (73.5%) had more NSTEMI when compared to White participants (65.9%). Black women and women with an income <$20,000 had higher proportions of diabetes and hypertension, and less physical activity than White women and women with an income ≥$20,000. Black women also had higher proportions of heart failure. Coronary heart disease prevalence was similar across racial, ethnic, and income groups.

Race/Ethnicity and Revascularization in AMI

Among women with AMI, Black women were less likely to receive coronary revascularization than White women [HR: 0.78 (95%CI: 0.65, 0.92)] in analyses adjusted for demographics, comorbidities, and AMI type (Table 2, Model 2). Hispanic and White women had a comparable likelihood of revascularization when presenting with AMI [HR: 1.07 (95%CI: 0.82, 1.38)]. With the inclusion of income in the fully adjusted analyses, the association of race/ethnicity with coronary revascularization was not attenuated, with Black women receiving less revascularization than White women [HR: 0.79 (95%CI: 0.66, 0.95); Table 2, Model 3]. Regarding the type of revascularization, Black women had a lower likelihood of receiving PCI [HR: 0.72 (95%CI: 0.59, 0.90)] and a similar likelihood of receiving CABG compared to White women in fully adjusted analyses. There was no

significant difference in the receipt of PCI or CABG between Hispanic and White women with AMI. Irrespective of MI type (STEMI or NSTEMI), individuals of Black race had a significantly lower likelihood of PCI than individuals of White race (Supplementary Table 2A and 2B).

Income and Revascularization in AMI

Annual income of <$20,000 was also associated with lower coronary revascularization for AMI. Women with an income <$20,000 were less likely to receive revascularization than women with an income ≥$20,000 after adjustment for demographics, comorbidities, and AMI type [HR: 0.89 (95%CI: 0.81, 0.98); Table 2, Model 2]. This pattern was also seen in the fully adjusted analyses, which added race [HR: 0.90 (95%CI: 0.82, 0.99); Table 2, Model 3]. There was no significant difference in the receipt of PCI or CABG between income categories. When further stratified by MI type, individuals with an income <$20,000 had significantly less revascularization for NSTEMI than individuals with an income ≥$20,000 (Supplementary Table 2B).

Secular Trends

From 2005 to 2019, the cumulative incidence of revascularization increased across all racial/ethnic groups and income levels (Figure 2A and 2B). Despite the increase in revascularization, the racial disparities remained, with Black and His panic women persistently receiving less coronary revascularization than their White counterparts when presenting with AMI. The annualized data showed comparable incidence of revascularization among women with <$20,000 versus ≥$20,000 annual income(Figure 2A and 2B).

When the time interval was divided into pre-and post-2010, the Black and White race differences in coronary revascularization were significant (Figure 3). Black participants were less likely to be revascularized for AMI (p=0.01), and hazards ratio of revascularization did not change between the pre- and post-2010 time periods (p=0.26). Throughout both time periods, Hispanic participants had similar hazards ratio of revascularization to White participants for the treatment AMI (p=0.52), and hazards ratio of revascularization was similar between the pre- and post-2010 time periods (p=0.78). Participants with annual income <$20,000 was associated with lower revascularization hazards ratio than participants with income ≥$20,000 (p=0.04); hazards ratio of revascularization was similar across time periods (p=0.47).

DISCUSSION

In a large cohort of postmenopausal women with AMI, Black women and women with <$20,000 annual income were significantly less likely to receive coronary revascularization for AMI than non-Hispanic White women and women with ≥$20,000 annual income. Disparities stratified by revascularization type were significant only among Black and White women receiving PCI. Disparities were not attenuated by accounting for social determinants of health such as education, insurance, and did not change after adjusting for intersectionality of race, ethnicity, and annual income. There were no differences in

likelihood of revascularization for AMI between Hispanic and White women. No significant changes in disparities were observed in the past two decades.

The association between race and clinical outcomes in AMI has been limited in contemporary research. Our study adds to the existing literature[29–31] by showing the continued association of Black race and decreased likelihood of coronary revascularization when presenting with AMI. Multiple mechanisms may explain the persistent relationship between race and receipt of coronary revascularization for AMI. There may be misconceptions about the pre-test probability of obstructive coronary artery disease by race, leading to less revascularization. A couple of studies have observed less obstructive coronary artery disease in Black patients than White patients presenting with similar symptoms,[32,33] however, another national study found similar levels of obstructive CAD in Black and White women.[34] Race is a social construct and should be studied from a social context rather than a genetically defined risk context.[35]

Second, insurance barriers are related to racial disparities in revascularization. Black and Hispanic populations represent a minority of the U.S.' public beneficiaries and uninsured populations but have disproportionately higher public insurance and uninsurance levels than White populations.[36] We adjusted for insurance type in this study, but the majority of patients had public insurance, and many qualify for Medicare. Although the Affordable Care Act Medicaid Expansion has been associated with an increased likelihood of people of color being transferred to hospitals that offer PCI and for receiving revascularization following AMI,[37] racial disparities persist among different insurance categories. Private insurance remains a known factor associated with higher likelihood of receiving cardiovascular specialty care.[38]

Lastly, bias and structural racism may contribute to lower referral rates to cardiologists and ultimately lower invasive strategies. Multiple studies have demonstrated racial and gender bias against offering invasive cardiovascular care to Black patients and female patients, particularly Black women.[39–42] While patient choice could contribute to lower coronary angiography rates; this has been refuted by a study that found that Black-White race differences in receiving coronary angiography were significantly reduced when cardiology was consulted and recommended a procedure.[38] Both inclusion of a cardiologist and appropriate recommendations for procedures may be a major contributor to cardiovascular equity in AMI.

Prior studies have found striking income disparities for coronary revascularization procedures.[5,33,43–45] Similarly, our analysis reveals a significant difference in the rate of coronary revascularization according to income strata. The intersectionality of race and income has been associated with a lower likelihood of PCI for AMI among Black and White individuals in low-income versus higher-income neighborhoods.[44] Income, along with race or ethnicity, are related to multiple social determinants of health. Forms of structural racism such as redlining have used government laws and policies to create areas of high neighborhood deprivation index (NDI) with low financial capital, specifically for people of color. Reduced access to quality hospitals and timely emergency care in these areas may

results in lower revascularization for the treatment of AMI among patients of lower income and patients of color.[46–49]

Our findings are particularly noteworthy as Black race and lower-income level continue to be associated with a decreased likelihood of receiving revascularization for AMI. The racial difference in therapy was observed in PCI, but not CABG. This is concerning given that PCI can be life-saving in AMI, and Black patients have consistently higher rates of death from coronary artery disease.[33] Our study is aimed at raising awareness about persistent racial, gender, and income related disparities with potentially life-saving cardiovascular care. We advocate for pre-emptive management of bias in decision-making, changes of policies that support structural racism, and management of social determinants of health, which may eliminate disparities in treatment.

Research has revealed how patients of color receive inferior treatment. A U.S. meta-synthesis about clinician decision-making revealed that clinicians offer unequal care to patients of color due to misconceptions about meaning of race, patient-level issues (comorbidities, access barriers), system-level issues (inadequate ancillary support, time), patient values (trust), communication (culturally appropriate), as well as bias and racism.[42] Therefore, each of these issues should be addressed with each patient. Implementation science frameworks informed by patient and clinical stakeholders can be used to identify the best strategies to address each factor and followed by testing to optimize receipt of appropriate therapies such as PCI. This may be the best way to ensure that cardiologists are offering PCI equitably across race, ethnicity, income, gender, and the intersections of these important groups. Consideration of these processes with each clinical trial may improve the translation of evidence-based therapies to everyday equitable practice.

We acknowledge limitations in our analysis. First, WHI did not adjudicate for coronary angiography results, and we cannot confirm the appropriateness of revascularization or the time between presentation and revascularization in minutes or hours; thus, we are unable to quantify all quality and performance measures for revascularization. However, appropriate treatment of STEMI includes prompt revascularization,[50] and we identified consistent differences in revascularization by race and income after adjusting for AMI type as well as demographics and comorbidities. Second, we could not determine the presence of uncontrolled co-occurring diseases that might result in type II demand AMI other than known comorbidities. Such clinical presentations could appropriately nullify the need for coronary reperfusion among these postmenopausal women. Third, WHI data does not include neighborhood deprivation index, but several of the factors in neighborhood deprivation index were included in the analyses. Fourth, WHI data includes data at the level of the individual, not at the level of hospital or larger healthcare system. Therefore, we cannot ascertain the type of hospital a patient may have presented to initially, or any subsequent transfers to PCI capable hospitals. Lastly, we do not know the role of shared decision-making in the option to offer revascularization. Discordance between patient and healthcare professional goals could be linked with results.

CONCLUSION

Among postmenopausal women participating in one of the largest and longest population studies of women, we found that Black race and income <$20,000 were associated with lower likelihood of coronary revascularization among patients presenting with AMI than patients with White race and income ≥$20,000 respectively. No significant differences were observed among patients of Hispanic ethnicity and Non-Hispanic White ethnicity. Our findings suggest that race and income merit consideration in the complex management of AMI. Additional investigation with patients, community stakeholders, and healthcare professionals is needed to develop timely interventions that invoke anti-racist principles.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGMENTS

We express gratitude towards the WHI participants, clinical sites, investigators, and staff of which otherwise this study would not be possible.

Source of Funding

Dr. Breathett has research funding from National Heart, Lung, and Blood Institute (NHLBI) R56HL159216, K01HL142848, R25HL126146 subaward 11692sc, and L30HL148881; and Women As One. The Women's Health Initiative program is funded by the National Heart, Lung, and Blood Institute, National Institutes of Health, U.S. Department of Health and Human Services through contracts HHSN268201100046C, HHSN268201100001C, HHSN268201100002C, HHSN268201100003C, HHSN268201100004C, and HHSN271201100004C.

REFERENCES

1. Framke E, Sorensen JK, Andersen PK, Svane-Petersen AC, Alexanderson K, Bonde JP, Farrants K, Flachs EM, Hanson LLM, Nyberg ST, Villadsen E, Kivimaki M, Rugulies R, Madsen IEH. Contribution of income and job strain to the association between education and cardiovascular disease in 1.6 million Danish employees. Eur Heart J 2020;41:1164–1178. [PubMed: 31844881]
2. Magnani JW, Mujahid MS, Aronow HD, Cené CW, Dickson VV, Havranek E, Morgenstern LB, Paasche-Orlow MK, Pollak A, Willey JZ. Health literacy and cardiovascular disease: fundamental relevance to primary and secondary prevention: a scientific statement from the American Heart Association. Circulation 2018;138:e48–e74. [PubMed: 29866648]
3. Safford MM, Reshetnyak E, Sterling MR, Richman JS, Muntner PM, Durant RW, et al. Number of Social Determinants of Health and Fatal and Nonfatal Incident Coronary Heart Disease in the REGARDS Study. Circulation 2021;143(3):244–253. [PubMed: 33269599]
4. Graham G, Xiao Y-YK, Rappoport D, Siddiqi S. Population-level differences in revascularization treatment and outcomes among various United States subpopulations. World J Cardiol 2016;8:24–40. [PubMed: 26839655]
5. Singh JA, Lu X, Ibrahim S, Cram P. Trends in and disparities for acute myocardial infarction: an analysis of Medicare claims data from 1992 to 2010. BMC Med 2014;12:190–190. [PubMed: 25341547]
6. Bolorunduro OB, Kiladejo AV, Animashaun IB, Akinboboye OO. Disparities in Revascularization After ST Elevation Myocardial Infarction (STEMI) Before and After the 2002 IOM Report. Journal of the National Medical Association 2016;108:119–123. [PubMed: 27372472]
7. Hess N, Seese L, Sultan I, Mulukutla S, Marroquin O, Gleason T, Fallert M, Wang Y, Thoma F, Kilic A. The Impact of Race on Outcomes of Revascularization for Multivessel Coronary Artery Disease. The Annals of thoracic surgery 2020.

8. Alkhouli M, Alqahtani F, Kalra A, Gafoor S, Alhajji M, Alreshidan M, Holmes DR, Lerman A. Trends in Characteristics and Outcomes of Patients Undergoing Coronary Revascularization in the United States, 2003–2016. JAMA Netw Open 2020;3:e1921326. [PubMed: 32058558]

9. Roswell R, Kunkes J, Ghumman M, Bangalore S. GENDER DISPARITY IN THE NEW ACC/AHA RECOMMENDED REPERFUSION TIME IN ACUTE STEMI PATIENTS. Journal of the American College of Cardiology 2015;65:A99.

10. Graham G. Acute coronary syndromes in women: recent treatment trends and outcomes. Clinical Medicine Insights: Cardiology 2016;10:CMC. S37145.

11. Wei J, Mehta PK, Grey E, Garberich RF, Hauser R, Bairey Merz CN, Henry TD. Sex-based differences in quality of care and outcomes in a health system using a standardized STEMI protocol. Am Heart J 2017;191:30–36. [PubMed: 28888267]

12. Gnavi R, Rusciani R, Dalmasso M, Giammaria M, Anselmino M, Roggeri DP, Roggeri A. Gender, socioeconomic position, revascularization procedures and mortality in patients presenting with STEMI and NSTEMI in the era of primary PCI. Differences or inequities? International journal of cardiology 2014;176:724–730. [PubMed: 25183535]

13. Schroder SL, Richter M, Schroder J, Frantz S, Fink A. Socioeconomic inequalities in access to treatment for coronary heart disease: A systematic review. International Journal of Cardiology 2016;219:70–78. [PubMed: 27288969]

14. Havranek EP, Mujahid MS, Barr DA, Blair IV, Cohen MS, Cruz-Flores S, Davey-Smith G, Dennison-Himmelfarb CR, Lauer MS, Lockwood DW, Rosal M, Yancy CW, American Heart Association Council on Quality of C, Outcomes Research CoE, Prevention CoC, Stroke Nursing CoL, Cardiometabolic H, Stroke C. Social Determinants of Risk and Outcomes for Cardiovascular Disease: A Scientific Statement From the American Heart Association. Circulation 2015;132:873–898. [PubMed: 26240271]

15. Pahigiannis K, Thompson-Paul AM, Barfield W, Ochiai E, Loustalot F, Shero S, Hong Y. Progress Toward Improved Cardiovascular Health in the United States: Healthy People 2020 Heart Disease and Stroke Objectives. Circulation 2019;139:1957–1973. [PubMed: 30986104]

16. Gallery LI, People eLearning H, Workgroup FI, Agencies LF. Visit coronavirus. gov for the latest Coronavirus Disease (COVID-19) updates

17. Health CfDCaPNIo. Heart Disease and Stroke: Healthy People 2010 2000:3–33.

18. Guzman LA, Li S, Wang TY, Daviglus ML, Exaire J, Rodriguez CJ, Torres VI, Funk M, Saucedo J, Granger C. Differences in Treatment Patterns and Outcomes Between Hispanics and Non-Hispanic Whites Treated for ST-Segment Elevation Myocardial Infarction: Results From the NCDR ACTION Registry–GWTG. Journal of the American College of Cardiology 2012;59:630–631. [PubMed: 22300700]

19. Cohen MG, Roe MT, Mulgund J, Peterson ED, Sonel AF, Menon V, Smith SC Jr., Saucedo JF, Lytle BL, Pollack CV Jr., Garza L, Gibler WB, Ohman EM. Clinical characteristics, process of care, and outcomes of Hispanic patients presenting with non-ST-segment elevation acute coronary syndromes: results from Can Rapid risk stratification of Unstable angina patients Suppress ADverse outcomes with Early implementation of the ACC/AHA Guidelines (CRUSADE). Am Heart J 2006;152:110–117. [PubMed: 16824839]

20. Golomb M, Redfors B, Crowley A, Smits PC, Serruys PW, von Birgelen C, Madhavan MV, Ben-Yehuda O, Mehran R, Leon MB, Stone GW. Prognostic Impact of Race in Patients Undergoing PCI: Analysis From 10 Randomized Coronary Stent Trials. JACC Cardiovasc Interv 2020;13:1586–1595. [PubMed: 32646701]

21. Coughlin SS, Young L. Social Determinants of Myocardial Infarction Risk and Survival: A Systematic Review. European journal of cardiovascular research 2020;1.

22. Chan PS, Patel MR, Klein LW, Krone RJ, Dehmer GJ, Kennedy K, Nallamothu BK, Weaver WD, Masoudi FA, Rumsfeld JS. Appropriateness of percutaneous coronary intervention. Jama 2011;306:53–61. [PubMed: 21730241]

23. Prentice RL AG, Cummings S, Freedman LS, Furberg C, Henderson M, Furberg C, Henderson M, Johnson SR, Kuller L, Manson J, Oberman A, Prentice RL, Rossouw JE, Finnegan L, Hiatt R, Pottern L, McGowan J, Clifford C, Caan B, Kipnis V, Ettinger B, Sidney S, Bailey G, LaCroix A, McTiernan A, Bowen D, Chen C, Cochrane B, Hunt J, Kristal A, Lund B, Patterson R, Probstfield J, Tinker J, Urban N, Wang CW, White E, Kotchen JM, Shumaker S, Rautaharju P,

Rautaharju F, Stein E, Laskarzewski P, Steiner P, Sagar K, Nevitt M, Dockrell M, Fuerst T, Himes J, Stevens M, Cammarata F, Lindenfelser S, Psaty B, Siscovick D, Longstreth W, Heckbert S, Wassertheil-Smoller S, Frishman W, Wylie-Rosett J, Barad D, Freeman R, Miller S, Hays J, Young R, Crowley C, DePoe MA, Burke G, Paskett E, Wagenknecht L, Crouse R, Parsons L, Kotchen T, Braunwald E, Buring J, Hennekens C, Gaziano JM, Assaf AR, Carleton R, Miller M, Wheeler C, Hume A, Pedersen M, Strickland O, Huber M, Porter V, Beresford S, Taylor V, Woods N, Hsia J, Barnabei V, Bovun M, Chlebowski R, Detrano R, Nelson A, Heiner J, Pushkin S, Valanis B, Stevens V, Whitlock E, Karanja N, Clark. . Design of the Women's health initiative clinical trial and observational study. Control Clinical Trials 1998;19(1):61–109.

24. Protocols and study consents. THE WOMEN'S HEALTH INITIATIVE. [Internet]. https://www.whi.org/page/protocols-and-study-consents. Accessed December 17, 2020
25. Hamad R, Elser H, Tran DC, Rehkopf DH, Goodman SN. How and why studies disagree about the effects of education on health: A systematic review and meta-analysis of studies of compulsory schooling laws. Social Science & Medicine 2018;212:168–178. [PubMed: 30036767]
26. Curb JD, McTiernan A, Heckbert SR, Kooperberg C, Stanford J, Nevitt M, Johnson KC, Proulx-Burns L, Pastore L, Criqui M, Daugherty S. Outcomes ascertainment and adjudication methods in the Women's Health Initiative. Ann Epidemiol 2003;13:S122–128. [PubMed: 14575944]
27. Semega JL, Fontenot KR, Kollar MA. Income and poverty in the United States: 2016. Current Population Reports 2017(P60-259):1–72. https://www.census.gov/content/dam/Census/library/publications/2017/demo/P60-259.pdf. Accessed November 6, 2020
28. Heckbert SR, Kooperberg C, Safford MM, Psaty BM, Hsia J, McTiernan A, Gaziano JM, Frishman WH, Curb JD. Comparison of self-report, hospital discharge codes, and adjudication of cardiovascular events in the Women's Health Initiative. American journal of epidemiology 2004;160:1152–1158. [PubMed: 15583367]
29. Ayanian JZ, Udvarhelyi IS, Gatsonis CA, Pashos CL, Epstein AM. Racial Differences in the Use of Revascularization Procedures After Coronary Angiography. JAMA 1993;269:2642–2646. [PubMed: 8487447]
30. Conigliaro J, Whittle J, Good CB, Hanusa BH, Passman LJ, Lofgren RP, Allman R, Ubel PA, O'Connor M, Macpherson DS. Understanding Racial Variation in the Use of Coronary Revascularization Procedures: The Role of Clinical Factors. Archives of Internal Medicine 2000;160:1329–1335. [PubMed: 10809037]
31. Akhter N, Milford-Beland S, Roe MT, Piana RN, Kao J, Shroff A, Cardiology ACo, Investigators NCDR. Gender differences among patients with acute coronary syndromes undergoing percutaneous coronary intervention in the American College of Cardiology-National Cardiovascular Data Registry (ACCNCDR). American heart journal 2009;157:141–148. [PubMed: 19081410]
32. Whittle J, Conigliaro J, Good CB, Hanusa BH, Macpherson DS. Black–white differences in severity of coronary artery disease among individuals with acute coronary syndromes. Journal of general internal medicine 2002;17:876–882.
33. Virani SS, Alonso A, Benjamin EJ, Bittencourt MS, Callaway CW, Carson AP, Chamberlain AM, Chang AR, Cheng S, Delling FN. Heart disease and stroke statistics—2020 update: a report from the American Heart Association. Circulation 2020:E139–E596.
34. Eastwood J-A, Johnson BD, Rutledge T, Bittner V, Whittaker KS, Krantz DS, Cornell CE, Eteiba W, Handberg E, Vido D. Anginal symptoms, coronary artery disease, and adverse outcomes in Black and White women: the NHLBI-sponsored Women's Ischemia Syndrome Evaluation (WISE) study. Journal of women's health 2013;22:724–732.
35. Breathett K, Spatz ES, Kramer DB, Essien UR, Wadhera RK, Peterson PN, Ho PM, Nallamothu BK. The groundwater of racial and ethnic disparities research: a statement From Circulation: Cardiovascular Quality and Outcomes. Circulation: Cardiovascular Quality and Outcomes 2021; 14(2): e007868. doi: 10.1161/CIRCOUTCOMES.121.007868 [PubMed: 33567860]
36. (SHADAC) SHADAC. State Health Compare: Health Insurance Coverage Type 2020.
37. Valdovinos EM, Niedzwiecki MJ, Guo J, Hsia RY. The association of Medicaid expansion and racial/ethnic inequities in access, treatment, and outcomes for patients with acute myocardial infarction. PloS one 2020;15:e0241785. [PubMed: 33175899]

38. LaVeist TA, Arthur M, Morgan A, Plantholt S, Rubinstein M. Explaining racial differences in receipt of coronary angiography: the role of physician referral and physician specialty. Medical Care Research and Review 2003;60:453–467. [PubMed: 14677220]
39. Schulman KA, Berlin JA, Harless W, Kerner JF, Sistrunk S, Gersh BJ, Dube R, Taleghani CK, Burke JE, Williams S. The effect of race and sex on physicians' recommendations for cardiac catheterization. New England Journal of Medicine 1999;340:618–626.
40. Daugherty SL, Blair IV, Havranek EP, Furniss A, Dickinson LM, Karimkhani E, Main DS, Masoudi FA. Implicit gender bias and the use of cardiovascular tests among cardiologists. Journal of the American Heart Association 2017;6:e006872. [PubMed: 29187391]
41. Breathett K, Yee E, Pool N, Hebdon M, Crist JD, Yee RH, Knapp SM, Solola S, Luy L, Herrera-Theut K. Association of gender and race with allocation of advanced heart failure therapies. JAMA network open 2020;3:e2011044–e2011044. [PubMed: 32692370]
42. Breathett K, Jones J, Lum HD, Koonkongsatian D, Jones CD, Sanghvi U, Hoffecker L, McEwen M, Daugherty SL, Blair IV. Factors related to physician clinical decision-making for African-American and Hispanic patients: a qualitative meta-synthesis. Journal of racial and ethnic health disparities 2018;5:1215–1229. [PubMed: 29508374]
43. Yong CM, Abnousi F, Asch SM, Heidenreich PA. Socioeconomic inequalities in quality of care and outcomes among patients with acute coronary syndrome in the modern era of drug eluting stents. Journal of the American Heart Association 2014;3:e001029. [PubMed: 25398888]
44. Rose KM, Foraker RE, Heiss G, Rosamond WD, Suchindran CM, Whitsel EA. Neighborhood socioeconomic and racial disparities in angiography and coronary revascularization: the ARIC surveillance study. Annals of epidemiology 2012;22:623–629. [PubMed: 22809799]
45. Kilpi F, Silventoinen K, Konttinen H, Martikainen P. Early-life and adult socioeconomic determinants of myocardial infarction incidence and fatality. Soc Sci Med 2017;177:100–109. [PubMed: 28161668]
46. Gangopadhyaya A. Black Patients Are More Likely Than White Patients to Be in Hospitals with Worse Patient Safety Conditions [Internet]. 2021. https://psnet.ahrq.gov/issue/black-patients-are-more-likely-white-patients-be-hospitals-worse-patient-safety-conditions. Accessed May 20, 2021.
47. Capers Q, Sharalaya Z. Racial disparities in cardiovascular care: a review of culprits and potential solutions. Journal of Racial and Ethnic Health Disparities 2014;1:171–180.
48. Hanchate AD, Paasche-Orlow MK, Baker WE, Lin M-Y, Banerjee S, Feldman J. Association of race/ethnicity with emergency department destination of emergency medical services transport. JAMA network open 2019;2:e1910816–e1910816. [PubMed: 31490537]
49. Hsia RY, Sarkar N, Shen Y-C. Impact of ambulance diversion: black patients with acute myocardial infarction had higher mortality than whites. Health Affairs 2017;36:1070–1077. [PubMed: 28583966]
50. Jneid H, Addison D, Bhatt D, Fonarow G, Gokak S, Grady K. Committee Members of 2017 AHA/ACC Clinical Performance and Quality Measures for Adults With ST-Elevation and Non ST-Elevation Myocardial Infarction: A Report of the American College of Cardiology/American Heart Association Task Force on Performance Measures. J Am Coll Cardiol [Internet] 2017:2048–2090.

HIGHLIGHTS

- Black race remains associated with less coronary revascularization post AMI.
- Hispanic women had similar likelihood of revascularization as White women post AMI.
- Annual income <$20,000 is associated with less coronary revascularization post AMI.
- Race, ethnicity, and income merit consideration in the complex management of AMI.

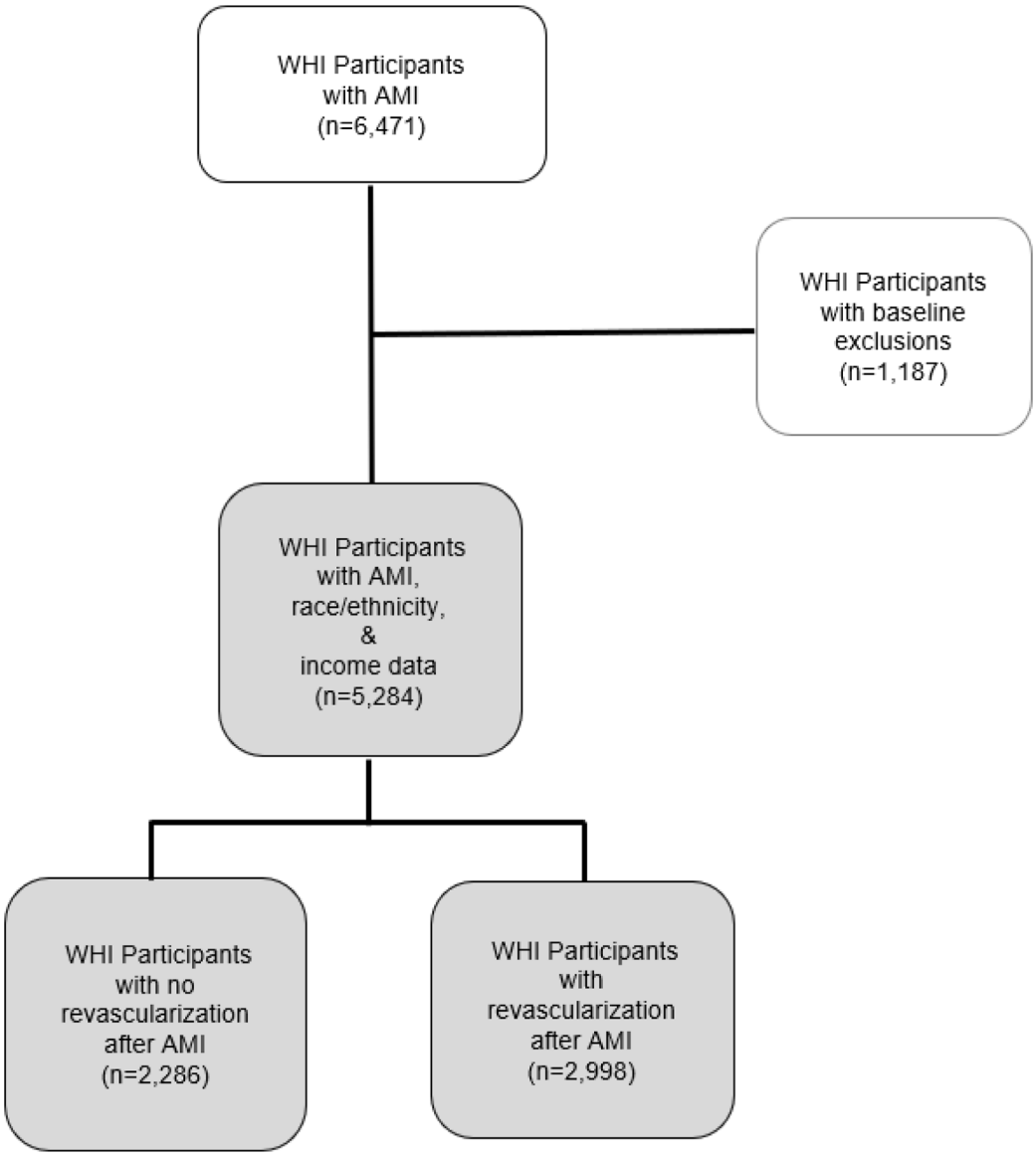

Figure 1. Study Profile.

Exclusion Criteria: missing race/ethnicity (n=19), missing or unknown income (n=410), unable to classify MI type (n=152), self-reported MI at enrollment (n=512), race/ethnicity specified as other (n=174). These numbers are not mutually exclusive.

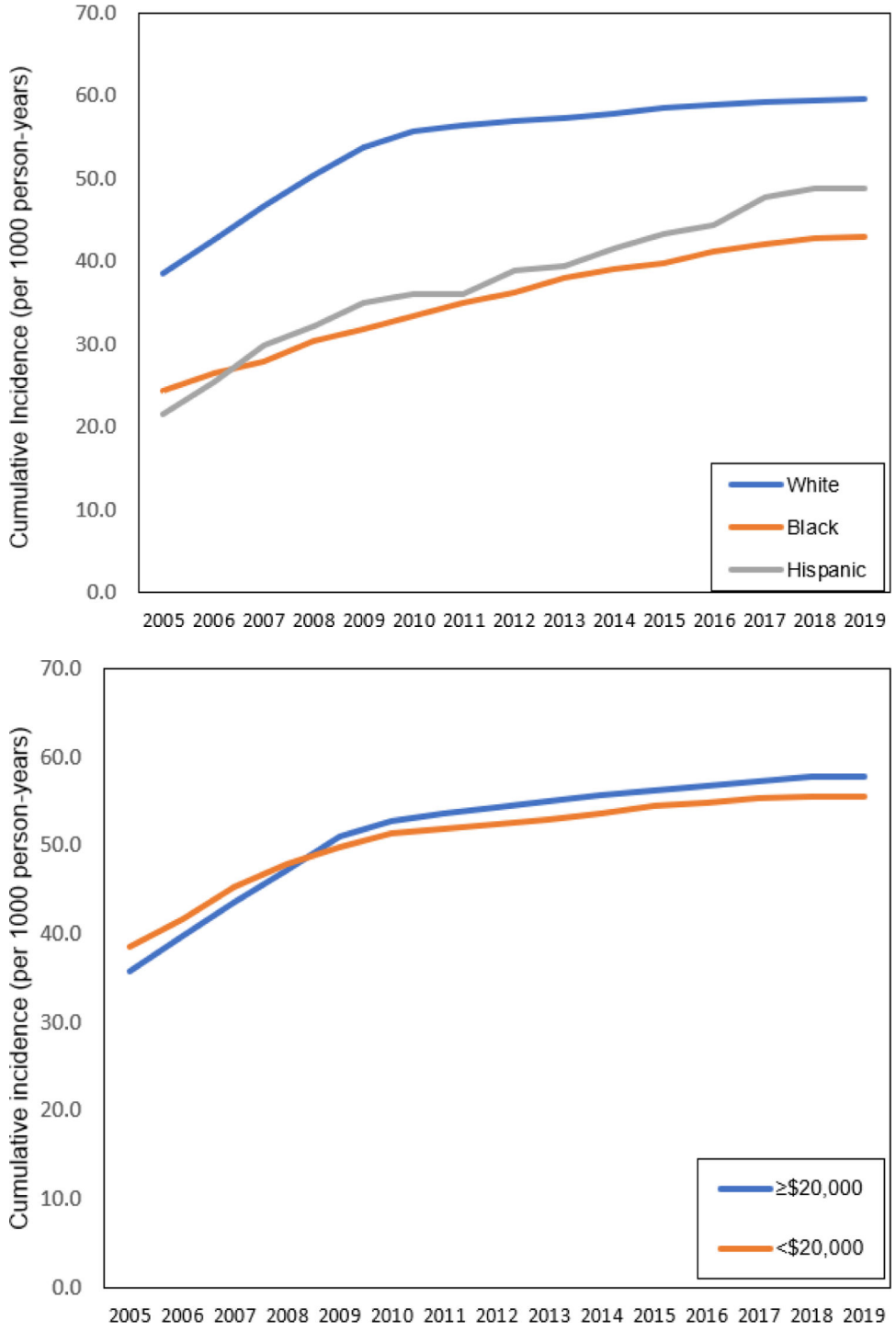

Figure 2. Annualized Trends in Revascularization Incidence (per-1000 person-years) Among Postmenopausal Women with AMI (2005–2019).

Figure 2A demonstrates trends by race and ethnicity with White race indicated by a blue line; Black race, orange line; Hispanic ethnicity, gray line. **Figure 2B**. Trends by annual income <$20,000 is indicated with an orange line; ≥$20,000, blue line.

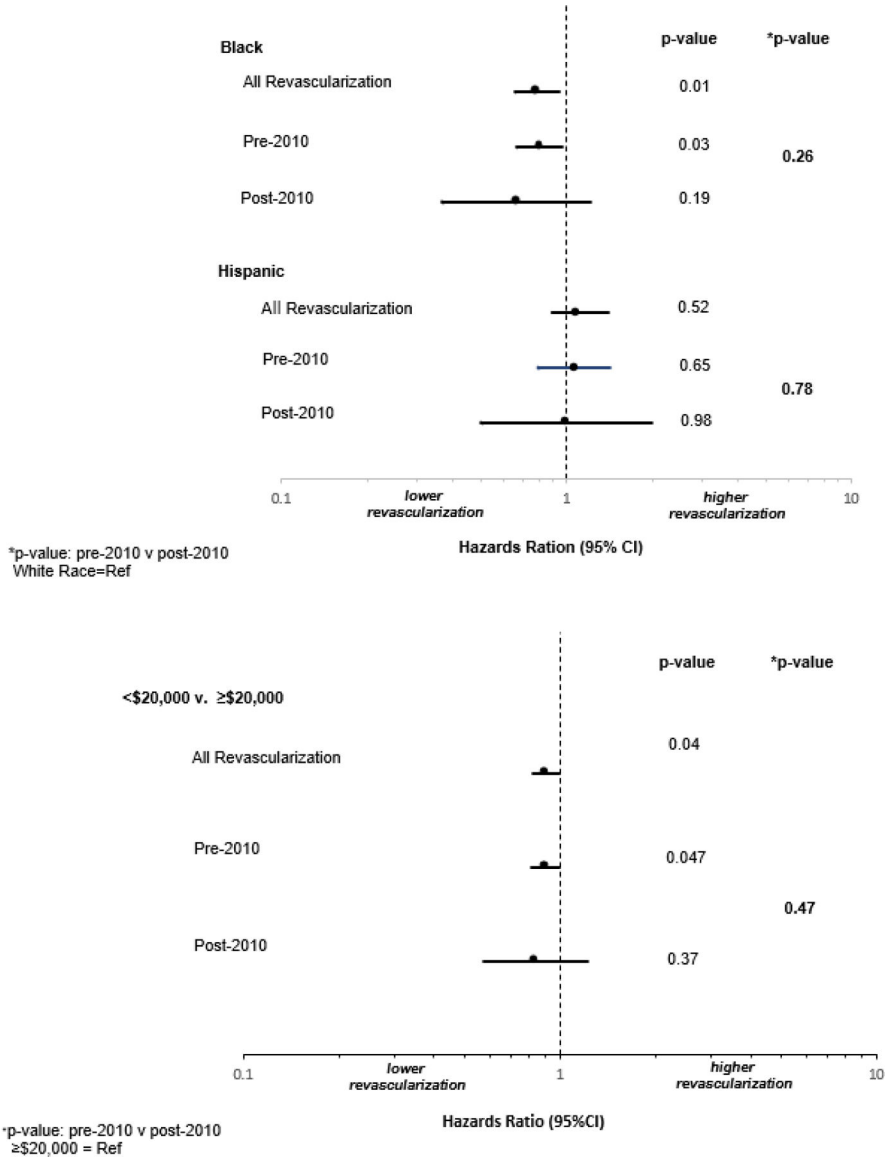

Figure 3. Revascularization Rates by Race and Ethnicity and Income level Pre- and Post-2010.
*p-value indicates interaction between time period of revascularization and race and ethnicity or income.

Table 1.

Baseline characteristics in WHI Study population with AMI

		Race/Ethnicity				Income Level		
	Total Sample	**Black**	**White**	**Hispanic**		**Income ≥ $20K**	**Income < $20K**	
Variable	***(n=5,284)***	***(n=502)***	***(n=4,635)***	***(n=147)***	***p-value***	***(n=4,058)***	***(n=1,226)***	***p-value***
Age [mean, sd]	66.3 (6.8)	63.7 (7.0)	66.7 (6.7)	62.3 (6.8)	<0.01	65.9 (6.8)	67.6 (6.7)	<0.01
BMI [mean, sd]	29.0 (6.2)	32.0 (6.5)	28.7 (6.1)	29.3 (6.3)	<0.01	28.8 (6.2)	29.8 (6.2)	<0.01
Race								
Non-Hispanic Black	502 (9.5)	---	---	---		332 (8.2)	170 (13.9)	<0.01
Non-Hispanic White	4635 (87.7)	---	---	---		3637 (89.6)	998 (81.4)	
Hispanic	147 (2.8)	---	---	---		89 (2.2)	58 (4.7)	
Education					<0.01			<0.01
Less than High School	310 (5.9)	63 (12.6)	211 (4.6)	36 (24.8)		132 (3.3)	178 (14.6)	
High School graduate	1140 (21.7)	73 (14.6)	1047 (22.7)	20 (13.8)		778 (19.3)	362 (29.7)	
Some College	2107 (40.1)	216 (43.2)	1828 (39.7)	63 (43.5)		1591 (39.4)	516 (42.3)	
College graduate	1697 (32.3)	148 (29.6)	1523 (33.0)	26 (17.9)		1534 (38.0)	163 (13.4)	
Income (% annual household)					<0.01			<0.01
≥$50,000	1378 (26.1)	111 (22.1)	1241 (26.8)	26 (17.7)		1378 (34.0)	0 (0.0)	
$20,000-$49,999	2680 (50.7)	221 (44.0)	2396 (51.7)	63 (42.9)		2680 (66.0)	0 (0.0)	
<$20,000	1226 (23.2)	170 (33.9)	998 (21.5)	58 (39.5)		0 (0.0)	1226 (100.0)	
WHI Study Status					0.27			<0.01
OS participant	2544 (48.2)	228 (45.4)	2239 (48.3)	77 (52.4)		2002 (49.3)	542 (44.2)	
CT participant	2740 (51.8)	274 (54.6)	2396 (51.7)	70 (47.6)		2056 (50.7)	684 (55.8)	
Insurance Status					<0.01			<0.01
Private Only	2191 (41.5)	243 (48.4)	1877 (40.5)	71 (48.3)		1872 (46.1)	319 (26.0)	
Public	2861 (54.1)	224 (44.6)	2584 (55.8)	53 (36.1)		2082 (51.3)	779 (63.5)	
No insurance/ Unknown	232 (4.4)	35 (7.0)	174 (3.8)	23 (15.7)		104 (2.6)	128 (10.4)	
Marital Status					<0.01			<0.01
Married or partnered	2997 (56.8)	199 (39.7)	2717 (58.7)	81 (55.5)		2663 (65.7)	334 (27.3)	
Single/divorced/ widowed	2278 (43.2)	302 (60.3)	1911 (41.3)	65 (44.5)		1389 (34.3)	889 (72.7)	
Smoking Status					<0.01			<0.01
Never	2437 (46.9)	220 (44.8)	2140 (46.9)	77 (52.4)		1861 (46.6)	576 (47.8)	
Former	2183 (42.0)	185 (37.7)	1946 (42.7)	52 (35.4)		1728 (43.3)	455 (37.7)	
Current	578 (11.1)	86 (17.5)	474 (10.4)	18 (12.2)		403 (10.1)	175 (14.5)	

		Race/Ethnicity				Income Level		
	Total Sample	**Black**	**White**	**Hispanic**		**Income ≥ $20K**	**Income < $20K**	
Variable	***(n=5,284)***	***(n=502)***	***(n=4,635)***	***(n=147)***	***p-value***	***(n=4,058)***	***(n=1,226)***	***p-value***
Alcohol (servings/wk) [mean, sd]	2.04 (4.70)	0.88 (3.07)	2.19 (4.87)	1.10 (3.20)	<0.01	2.29 (4.73)	1.21 (4.53)	<0.01
Diabetes Mellitus	588 (11.1)	127 (25.3)	437 (9.4)	24 (16.3)	<0.01	399 (9.8)	189 (15.4)	<0.01
Atrial Fibrillation	310 (6.0)	28 (5.8)	276 (6.1)	6 (4.2)	0.65	228 (5.7)	82 (6.9)	0.14
Physical Activity (METhrs/wk) [mean, sd]	10.84 (12.53)	8.74 (12.71)	11.13 (12.56)	8.74 (10.14)	<0.01	11.39 (12.56)	8.99 (12.27)	<0.01
Heart Failure	86 (1.6)	19 (3.8)	65 (1.4)	2 (1.4)	<0.01	59 (1.5)	27 (2.2)	0.08
Family History of MI	768 (14.5)	53 (10.6)	699 (15.1)	16 (10.9)	<0.01	594 (14.6)	174 (14.2)	0.70
Hyperlipidemia	1044 (19.8)	105 (21.0)	907 (19.6)	32 (21.8)	0.63	802 (19.8)	242 (19.8)	0.99
Hypertension	2651 (50.2)	341 (67.9)	2246 (48.5)	64 (43.5)	<0.01	2000 (49.3)	651 (53.1)	0.02
Coronary Heart Disease	202 (3.8)	16 (3.2)	180 (3.9)	6 (4.1)	0.73	156 (3.8)	46 (3.8)	0.88
AMI Type					0.01			0.98
STEMI	1764 (33.4)	143 (28.5)	1582 (34.1)	39 (26.5)		1355 (33.4)	409 (33.4)	
NSTEMI	3520 (66.6)	359 (71.5)	3053 (65.9)	108 (73.5)		2703 (66.6)	817 (66.6)	
Region					<0.01			0.11
Northeast	1345 (25.5)	75 (14.9)	1252 (27.0)	18 (12.2)		1036 (25.5)	309 (25.2)	
South	1325 (25.1)	237 (47.2)	1038 (22.4)	50 (34.0)		987 (24.3)	338 (27.6)	
Midwest	1195 (22.6)	131 (26.1)	1058 (22.8)	6 (4.1)		924 (22.8)	271 (22.1)	
West	1419 (26.9)	59 (11.8)	1287 (27.8)	73 (49.7)		1111 (27.4)	308 (25.1)	

BMI, indicates body mass index in kilogram/meter^2; hrs, hours; MET, metabolic equivalents; public, Medicare/Medicaid/Military; SD, standard deviation; wk, week

Table 2.

Unadjusted and adjusted hazards ratio (HR) of coronary revascularization among postmenopausal women with AMI

	Crude		Model 1		Model 2		Model 3	
	HR (95% CI)	**p-value**	**HR (95% CI)**	**p-value**	**HR (95% CI)**	**p-value**	**HR (95% CI)**	**p-value**
Any revascularization								
Race								
Non-Hispanic White	Ref		Ref		Ref		Ref	
Non-Hispanic Black	0.99 (0.84,1.16)	0.87	0.98 (0.83, 1.15)	0.79	0.78 (0.65, 0.92)	<0.01*	0.79 (0.66, 0.95)	0.01*
Hispanic	1.18 (0.92,1.50)	0.19	1.16 (0.91, 1.48)	0.24	1.07 (0.82, 1.38)	0.62	1.09 (0.84, 1.41)	0.52
Income								
<20,000	0.97 (0.89,1.06)	0.56	0.98 (0.90, 1.07)	0.66	0.89 (0.81, 0.98)	0.02*	0.90 (0.82, 0.99)	0.04*
≥20,000	Ref		Ref		Ref		Ref	
PCI								
Race								
Non-Hispanic White	Ref		Ref		Ref		Ref	
Non-Hispanic Black	0.87 (0.72,1.06)	0.16	0.86 (0.71, 1.04)	0.12	0.71 (0.58, 0.88)	<0.01*	0.72 (0.59, 0.90)	<0.01*
Hispanic	1.17 (0.89,1.54)	0.27	1.14 (0.86, 1.50)	0.36	1.08 (0.80, 1.45)	0.61	1.10 (0.82, 1.48)	0.54
Income								
<20,000	0.95 (0.85,1.05)	0.28	0.96 (0.87, 1.06)	0.40	0.90 (0.81, 1.01)	0.07	0.92 (0.82, 1.03)	0.14
≥20,000	Ref		Ref		Ref		Ref	
CABG								
Race								
Non-Hispanic White	Ref		Ref		Ref		Ref	
Non-Hispanic Black	1.35 (1.02,1.79)	0.03*	1.37 (1.04, 1.81)	0.03*	0.95 (0.71, 1.29)	0.76	0.97 (0.72, 1.32)	0.86
Hispanic	0.98 (0.58,1.65)	0.93	1.00 (0.59, 1.68)	0.99	0.86 (0.51, 1.46)	0.58	0.88 (0.51, 1.49)	0.62
Income								
<20,000	1.12 (0.95,1.32)	0.17	1.11 (0.94, 1.31)	0.20	0.91 (0.76, 1.09)	0.30	0.91 (0.76, 1.10)	0.33
≥20,000	Ref		Ref		Ref		Ref	

Statistically significant values are denoted with * Model 1. adjusted for age.

Model 2. Model 1 plus adjustment for education, physical activity, smoking status, diabetes, hypertension, hyperlipidemia, heart failure, obesity, AMI type, insurance type, and region.

Model 3. Model 2 plus adjustment for race/ethnicity with income output -OR- Model 2 plus adjustment for income with race/ethnicity output.