NIH Public Access

Author Manuscript

Ann Epidemiol. Author manuscript; available in PMC 2010 December 1.

Published in final edited form as:

Ann Epidemiol. 2009 December ; 19(12): 867–874. doi:10.1016/j.annepidem.2009.07.092.

Neighborhood Disparities in Incident Hospitalized Myocardial Infarction in Four US Communities: The ARIC Surveillance Study

Kathryn M. Rose, PhD[1], **Chirayath M. Suchindran, PhD**[2], **Randi E. Foraker, MA**[1], **Eric A. Whitsel, MD, MPH**[1,3], **Wayne D. Rosamond, PhD**[1], **Gerardo Heiss, MD, PhD**[1], and **Joy L. Wood, MS**

[1] Department of Epidemiology, University of North Carolina, Chapel Hill, North Carolina

[2] Department of Biostatistics, University of North Carolina, Chapel Hill, North Carolina

[3] Department of Medicine, University of North Carolina, Chapel Hill, North Carolina

Abstract

Objectives—Hospital-based surveillance of myocardial infarction (MI) in the United States (US) typically includes age, gender, and race, but not socioeconomic status (SES). We examined the association between neighborhood median household income (nINC) and incident hospitalized MI in four US communities (1993–2002).

Methods—Average annual indirect age-standardized MI rates were calculated using community-specific and community-wide nINC tertiles. Poisson generalized linear mixed models were used to calculate MI incidence rate ratios by tertile of census tract nINC (high nINC group referent).

Results—Within community, and among all race-gender groups, those living in low nINC neighborhoods had an increased risk of MI compared to those living in high nINC neighborhoods. This association was present when both community-specific and community-wide nINC cutpoints were used. Blacks, and to a lesser extent women, were disproportionately represented in low nINC neighborhoods, resulting in a higher absolute burden of MI in blacks and women living in low compared to high nINC neighborhoods.

Conclusions—These findings suggest a need for the joint consideration of racial, gender and social disparities in interventions aimed at preventing coronary heart disease.

Keywords

Neighborhood income; socioeconomic status; myocardial infarction; community surveillance; gender; race

Introduction

Epidemiologic studies document socioeconomic disparities in coronary heart disease (CHD) morbidity and mortality in the United States (US) (1–4) and other western countries. (5–11) Because lower socioeconomic position individuals (12–15) and racial/ethnic minorities (12)

Corresponding Author: Kathryn M. Rose, PhD, Bank of America Center, 137 E Franklin St, Ste 306, Chapel Hill, NC 27514, Phone: 919-966-4596, Fax: 919-966-9800, kathryn_rose@unc.edu.

are typically under-represented in epidemiologic cohorts due to recruitment strategies and lower participation and retention rates, documented disparities may not accurately represent patterns in the underlying populations. In contrast, US and international community-based surveillance systems are designed to accurately estimate the rates of myocardial infarction (MI), CHD mortality and associated temporal trends within communities. Such information is an important complimentary tool for monitoring disparities in the burden of CHD.

European surveillance studies report inverse associations between education (8), income (8) and occupation (7) with incident fatal and nonfatal MI events as well as higher MI rates among middle-aged persons living in socially deprived neighborhoods (16,17). Neighborhood socioeconomic factors are associated, albeit moderately, with individual socioeconomic circumstances.(18,19) Moreover, there is evidence that the neighborhood socioeconomic context contributes to many health outcomes (1,20–27) and precedence for its inclusion in health surveillance systems. (19,24,28,29) Socioeconomic disparities in the burden of MI have not been systematically addressed in US surveillance efforts, largely due to the lack of socioeconomic data in medical records. However, patient addresses are universally collected for follow-up and billing, allowing linkage to census-based socioeconomic data. The Atherosclerosis Risk in Communities (ARIC) study's surveillance has documented rates and trends in CHD in four US communities by age, race, and gender for 21 years. (30,31) We extend this work to examine rates and trends in the incidence of hospitalized MI by neighborhood socioeconomic conditions and to determine if these differences vary by study community, race, gender, or year of MI event.

Methods

Overview

The ARIC study's community-based surveillance of CHD began in 1987 with methods previously described. (32) Potential acute hospitalized MI cases were identified via retrospective review of sampled hospital discharges among white and black residents aged 35–74 years from Forsyth County, North Carolina (NC); Jackson (city) Mississippi (MS); suburbs of Minneapolis, Minneapolis (MN); and Washington County, Maryland (MD). The NC and MS communities included both black and white residents, while the MD and MN communities were predominantly white.

Identification of MI Events

Annually, hospital discharge codes meeting age and residential inclusion criteria are obtained from participating hospitals. Sampling criteria (32) are applied to select cases for evaluation. Target ICD-9 primary or secondary discharge codes include: 402, 410–414, 427, 428, and 518.4. Centrally-trained staff review eligible records for presenting symptoms, medical history, and laboratory values. MIs are identified based on cardiac chest pain, cardiac biomarkers and standard twelve-lead electrocardiograms (33). Up to three electrocardiograms are recorded and classified using a standardized algorithm. Events are classified as definite, probable, suspect, or no MI by a computer-based algorithm. Hospitalizations occurring within 28 days are linked as one event. We included incident hospitalized definite or probable MI. An MI was defined as incident if there were no indications of prior MI in the medical history.

Defining Neighborhood SES

Addresses associated with MIs were geocoded by a vendor previously identified as assigning accurate geocodes. (34) We obtained exact address matches for 93% of addresses and matched an additional 2% to the census tract (CT). Assigned CT identifiers were used to link each event with 2000 US Bureau of the Census socioeconomic data. We used CT median household income (nINC) to represent neighborhood socioeconomic conditions. It is correlated with measures of poverty and has gradients with health outcomes comparable to those seen with a more complex index measure in this (35) and other studies. (28) nINC was classified into tertiles (low, medium, high) using both community-wide (overall) and community-specific cutpoints. Community-wide nINC cutpoints were based on the tertiles of median household incomes of the CTs across *all* study communities (high: >$50,032; medium: $33,533–50,032; low: <$33,533). Community-specific tertiles, based on the distribution of CT median household incomes *within* each study community, are presented in Table 1.

Population Denominators

Using 1990 and 2000 CT population counts normalized to conform to 2000 CT boundaries, we calculated age-, gender-, and race-specific population estimates for each CT for inter-censal and post-censal periods. We compared two approaches: a simple linear interpolation-extrapolation method and regression models that included nonlinear trends. The estimates from the two approaches were similar; thus, we present results for estimates from the simple linear interpolation-extrapolation method.

Exclusions

MI events occurring before 1993 were not included, as addresses were not abstracted before this time. Between 1993 and 2002, 10,500 (unweighted) definite or probable MIs were identified. We excluded patients with missing race or gender (n=136), age < 35 or > 74 years (n=52), a missing sampling weight (n=20), non-white race in Minneapolis or Washington County [because of insufficient numbers for analysis (N=145)], and missing/inadequate address information precluding assignment of a CT (n=533). Of 9,614 remaining events, we excluded 2,885 patients with a medical history of a prior MI, 547 patients with missing data on prior MI status, and 212 patients residing outside of the study area. Our final unweighted sample size was 5,970, with a weighted sample size of 8,239 patients.

Analyses

We generated a standard population by summing the age distribution represented by the total population combining both sexes and races and all ARIC study sites for the year 2000. A three year average weighted MI count for the years 1999 -2001 in eight age strata (35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74) was used to calculate age-specific event rates for the standard population. The indirect standardized rates for each CT were calculated by applying standard population rates to the age-, sex-, and race-specific population of each CT. This technique provided the expected number of events for each CT (gender- and race-specific) had the tract experienced the rate of the standard.

Using the expected and observed events (weighted for sampling) for each CT for specific race-gender groups, standardized incidence rate ratios (IRR) were calculated. Note that the age-adjusted (indirect) MI rate for a CT is calculated as the product of the IRR for the tract with the crude MI event rate of the standard population.

Poisson generalized linear mixed models were used to calculate IRRs for MI by tertile of nINC with the high nINC group as the referent. This technique calculates standard errors that account for clustering of MI cases within CTs. We examined effect modification by study community and year of MI, i.e. nINC*community and nINC*year interactions (p value < 0.05) in race-gender specific models. A second set of models assessed the association of nINC with incident MI within study communities, with race and gender included as covariates.

We estimated the proportionate burden of incident MI by nINC within race-gender groups. We used race-gender specific 2000 census population counts and the proportion of persons living in each nINC area (based on overall cutpoints) to derive expected race-gender-nINC population counts, then applied age-adjusted nINC-stratum specific MI rates to estimate the expected number of MI cases in each nINC stratum. The race-gender-nINC stratum-specific MI counts were divided by the total number of events within these groups to estimate the proportion of total MI cases within each nINC stratum.

Analyses were performed using SAS Version 9.1 (SAS Institute, Inc., Cary, NC).

Results

Table 1 presents information on the eligible study populations by race and gender as well as selected year 2000 census information. Blacks comprised 80% of the residents of Jackson, MS and 25% of the residents of Forsyth, NC. The Minneapolis suburbs and Washington County populations are predominantly white. The number of CTs within communities ranged from 31 in Washington County, MD to 75 in Forsyth, NC. Jackson, MS had the smallest average number of persons in the age range of 35–74 years, while the Minneapolis suburbs had the largest average number. The median household income varied from $25,480 in Jackson, MS to $54,508 in the Minneapolis suburbs.

nINC was markedly lower for blacks than whites, and within race groups, modestly lower for women than men ($27,898 for black women; $29,547 for black men; $45,572 for white women; and $45,871 for white men).

Comparison of nINC – Incident MI Across Study Communities

Figure 1 presents estimated age-adjusted, community-specific and race-gender-specific hospitalized incidence rates of MI per 100,000 persons (averaged across 10 years) by tertile of nINC.

Regardless of whether community-wide or community-specific cutpoints defined the nINC strata, the Minneapolis community had lower MI rates in each nINC strata than did other communities (Figure 1a and 1b). In the other communities, MI rates tended to be similar. An exception was a comparatively higher rate of incident MI among low nINC in Forsyth County, NC.

Inverse associations were seen between nINC and the incidence of hospitalized MI when community-specific cutpoints were used to define nINC tertiles (Figure 1a and 1b). When tertiles of nINC were established using community-wide cutpoints, stepwise, inverse gradients were generally seen between nINC and incident MI. An exception occurred in Minneapolis, MN, where those in the lowest nINC group had MI rates that were similar to those in the high nINC group. However, only two CTs and a small portion of the overall population resided in low nINC areas.

Association of nINC with Incident MI by Race and Gender

Figures 1c and 1d present the estimated average annual incident rate of hospitalized MI per 100,000 persons across the study communities by race and gender. When community-specific nINC tertiles were used (Figure 1c), there were inverse associations between nINC and the incidence of hospitalized MI in all race-gender groups except for white men, where rates were similar for those in high and medium nINC areas. When community-wide nINC cutpoints were used, inverse associations were seen in all race-gender groups (Figure 1d).

Estimation of Incidence Rate Ratio of MI by nINC

Models were fit using both community-wide and community-specific cutpoints. There was no significant effect modification of the nINC-incident MI association by year or study community; thus, in subsequent models these variables were included as covariates. When both overall and community-specific cutpoints were used, among all race-gender groups, those living in the low nINC neighborhoods had a significantly increased risk of MI than did those in the high nINC neighborhoods. The magnitude of this association ranged from a 1.2 fold increase in risk among white men to an approximately a two-fold increase in risk among black women. IRR were suggestive of a modest increase in risk among those living in medium nINC compared to high nINC neighborhoods, however, the confidence intervals sometimes included the null value. Specifically, when overall cutpoints were used, associations were not significant for black men and black women and when community-specific cutpoints were used associations were not significant for white men.

Burden of MI within nINC, by Race and Gender

Figure 2 shows the breakdown of MI cases within nINC tertiles for each race-gender group. Among blacks, most MI cases occurred among those living in low nINC areas (approximately 90% of men and 80% of women), while among whites, the MIs were more evenly distributed across nINC groups, with the middle nINC group being the modal category. The distribution of MI cases also varied by gender. Among both blacks and whites, the proportion of MI cases in low nINC groups was higher among women than men and the proportion of MI cases in high nINC groups was higher among men than women.

Discussion

We observed monotonic, inverse associations between nINC and the incidence of hospitalized MI in the four study communities regardless of whether community-wide or community-specific cutpoints defined tertiles of nINC. Similarly, across communities, in all race-gender groups, individuals residing in low nINC neighborhoods had a significantly increased risk of MI compared to those living in high nINC neighborhoods. Our findings are consistent with population-based European surveillance reports of inverse associations of MI with individual (7,8) and neighborhood (7,8,16,17) socioeconomic measures. Also, our findings are generally consistent with an earlier report based on the ARIC *cohort* study which investigated the association between neighborhood social factors and the incidence of CHD.(1)

The association between nINC and hospitalized MI did not vary across the 10 years of surveillance. This is not consistent with reports of increasing socioeconomic disparities in CHD mortality. (5,6,36–40) However, increasing socioeconomic disparities in CHD mortality are ostensibly driven by smaller or later declines in CHD mortality among those from lower compared to more affluent socioeconomic groups, (37–40) whereas studies of change in the incidence of MI across time are less common and patterns have not been as consistently demonstrated.(31,41,42)

Within nINC- and gender-specific groups, MI rates did not vary markedly by race, and when differences did occur, higher rates were seen more often among whites. Most of the burden of MI in blacks was concentrated among residents of low nINC neighborhoods as a result of the stronger nINC-MI association among blacks and their over-representation in the lowest nINC neighborhoods (in contrast to a more even distribution of MI cases across nINC groups among whites). Beyond informing targeted community-based primary prevention efforts, this has implications for secondary prevention and care, since a substantial burden of CHD in society manifests in MI survivors, among whom those with socioeconomic disadvantage are less likely to undergo coronary revascularization (43–45) and are more likely to experience higher case fatality. (17,46,47) Moreover, it illustrates the difficulty of disentangling the effects of racial and socioeconomic disparities in the occurrence of disease in our society.

CTs were the smallest unit of analysis available. While the CT is often considered a crude approximation of neighborhood characteristics, we are reassured that CTs are constructed to be socioeconomically similar and that studies that use block groups, the smallest geographical unit at which census data are generally available, produce similar results. (48) As our work uses surveillance data, we are limited to measures available in census data. There is a lack of consensus in the literature about which census measure best approximates the neighborhood socioeconomic context. In our developmental work, we found that nINC- MI associations were similar to those found when a composite neighborhood SES index was used as well as when other individual census measures were used (percentage of persons living below poverty, percentage of households headed by females).(49) The lack of individual-level data on risk factors, co-morbidities, medical history and insurance status of all persons in the communities make it difficult to explore factors that potentially mediate neighborhood SES disparities.

The two ARIC surveillance communities with substantial black populations are in the southern US, and may not be representative of populations in other regions of the country. However, the magnitude of variation in median household income by race seen in these communities was similar to those recently reported for national figures. (50) As there were relatively few blacks living in higher income neighborhoods, our estimates for high nINC blacks were less precise. This was also an issue for blacks in medium nINC neighborhoods when overall cutpoints were *used*. It is reassuring that when analyses were repeated using race-specific nINC cutpoints, the lower MI rates among those in the most affluent neighborhoods persisted in both black men and women (data not shown).

Our study used standardized criteria to validate hospitalized nonfatal MI cases. These cases represent a substantial portion of the burden of all CHD in these communities, and their accurate identification is crucial to optimally document and track disparities in hospital care and subsequent survival. However, the patterns of socioeconomic and racial disparities seen in hospitalized MI events may differ from other CHD events, including silent MIs and fatal CHD. Previous reports suggested that blacks are proportionately more likely have an out-of-hospital fatal CHD event than are whites (51), and that inverse socioeconomic gradients are stronger for out-of-hospital CHD events than for all incident MI events (8). We are currently linking neighborhood socioeconomic data to fatal CHD events in ARIC surveillance communities, which will allow us to examine this issue in a subsequent report.

ARIC is the only ongoing US population-based surveillance study of CHD that includes a wide age range, diverse communities, and biracial populations. Moreover, given that MIs occurred over ten years, we could estimate community-, race-, and gender-specific effects within nINC strata. Unlike cohort studies, the potential for selection bias is minimal, given the community-based surveillance approach that includes comprehensive case ascertainment. While the sequential cross-sectional “snapshot” surveillance approach is not optimal for assessing long-term risk of groups within a defined population, when assessing the burden of disease within communities across time, it may be preferable, as it more accurately reflects the dynamic nature of populations within geographic areas.

The deficit of socioeconomic information in US vital records used in disease surveillance systems has been previously discussed (52), and can be overcome by including neighborhood socioeconomic data. (19,28). Our work demonstrates its successful implementation in a community-based surveillance system relying on hospital records. The mechanisms whereby neighborhood socioeconomic conditions influence cardiovascular health are debated. Some consider neighborhood socioeconomic characteristics to be proxies for individual-level socioeconomic characteristics. However, when both are considered in analyses, independent neighborhood effects tend to persist. *(1, 53–55)* **T**here is growing evidence of the impact of socioeconomic characteristics of place of residence on factors that influence cardiovascular

NIH-PA Author Manuscript

NIH-PA Author Manuscript

health. These include access to healthy food, (56) structural features of the built environment, (57–59) psychological stress (60–62) and a higher prevalence of behaviors such as smoking (63–65) and physical inactivity. (65,66)

In summary, residents of socioeconomically disadvantaged neighborhoods were at greater risk of suffering an incident MI in the ARIC surveillance communities, with stronger inverse associations seen among women and blacks. We also note the higher burden of MI among blacks and women, as they are more likely to reside in socioeconomically deprived neighborhoods. These patterns and the association of race, gender, and socioeconomic conditions with post-MI health-related trajectories, point to the importance of their joint consideration in public health interventions aimed at CHD prevention.

Acknowledgments

This research was supported by NHLBI contract 1R01HL080287. The Atherosclerosis Risk in Communities Study is carried out as a collaborative study supported by National Heart, Lung, and Blood Institute contracts N01-HC-55015, N01-HC-55016, N01-HC-55018, N01-HC-55019, N01-HC-55020, N01-HC-55021 and N01-HC-55022. The authors thank the staff of the ARIC study for their important contributions. The authors thank Mehul Patel for his assistance in the preparation of the figures.

List of Abbreviations and Acronyms

ARIC Atherosclerosis Risk in Communities Study

CT Census tract

nINC Census tract median household income

CHD Coronary heart disease

IRR Incidence rate ratio

MD Maryland

MN Minnesota

MS Mississippi

MI Myocardial infarction

NC North Carolina

US United States

References

1. Diez Roux AV, Merkin SS, Arnett D, Chambless L, Massing M, Nieto FJ, et al. Neighborhood of residence and incidence of coronary heart disease. N Engl J Med 2001;345(2):99–106. [PubMed: 11450679]
2. Kraus JF, Borhani NO, Franti CE. Socioeconomic status, ethnicity, and risk of coronary heart disease. Am J Epidemiol 1980;111(4):407–14. [PubMed: 7377183]
3. Thurston RC, Kubzansky LD, Kawachi I, Berkman LF. Is the association between socioeconomic position and coronary heart disease stronger in women than in men? Am J Epidemiol 2005;162(1): 57–65. [PubMed: 15961587]
4. Diez-Roux AV, Nieto FJ, Muntaner C, Tyroler HA, Comstock GW, Shahar E, et al. Neighborhood environments and coronary heart disease: a multilevel analysis. Am J Epidemiol 1997;146(1):48–63. [PubMed: 9215223]

NIH-PA Author Manuscript

NIH-PA Author Manuscript

5. Bennett S. Socioeconomic inequalities in coronary heart disease and stroke mortality among Australian men, 1979–1993. Int J Epidemiol 1996;25(2):266–75. [PubMed: 9119551]
6. Hallqvist J, Lundberg M, Diderichsen F, Ahlbom A. Socioeconomic differences in risk of myocardial infarction 1971–1994 in Sweden: time trends, relative risks and population attributable risks. Int J Epidemiol 1998;27(3):410–5. [PubMed: 9698128]
7. Lang T, Ducimetiere P, Arveiler D, Amouyel P, Cambou JP, Ruidavets JB, et al. Incidence, case fatality, risk factors of acute coronary heart disease and occupational categories in men aged 30–59 in France. Int J Epidemiol 1997;26(1):47–57. [PubMed: 9126502]
8. Salomaa V, Niemela M, Miettinen H, Ketonen M, Immonen-Raiha P, Koskinen S, et al. Relationship of socioeconomic status to the incidence and prehospital, 28-day, and 1-year mortality rates of acute coronary events in the FINMONICA myocardial infarction register study. Circulation 2000;101(16): 1913–8. [PubMed: 10779456]
9. Rose G, Marmot MG. Social class and coronary heart disease. Br Heart J 1981;45(1):13–9. [PubMed: 7459161]
10. Woodward M, Shewry MC, Smith WC, Tunstall-Pedoe H. Social status and coronary heart disease: results from the Scottish Heart Health Study. Prev Med 1992;21(1):136–48. [PubMed: 1738765]
11. Kivimaki M, Lawlor DA, Davey Smith G, Kouvonen A, Virtanen M, Elovainio M, et al. Socioeconomic position, co-occurrence of behavior-related risk factors, and coronary heart disease: the Finnish Public Sector study. Am J Public Health 2007;97(5):874–9. [PubMed: 17395837]
12. Jackson R, Chambless LE, Yang K, Byrne T, Watson R, Folsom A, et al. Differences between respondents and nonrespondents in a multicenter community-based study vary by gender ethnicity. The Atherosclerosis Risk in Communities (ARIC) Study Investigators. J Clin Epidemiol 1996;49 (12):1441–46. [PubMed: 8970495]
13. Lissner L, Skoog I, Andersson K, Beckman N, Sundh V, Waern M, et al. Participation bias in longitudinal studies: experience from the Population Study of Women in Gothenburg, Sweden. Scand J Prim Health Care 2003;21(4):242–7. [PubMed: 14695076]
14. Manjer J, Carlsson S, Elmstahl S, Gullberg B, Janzon L, Lindstrom M, et al. The Malmo Diet and Cancer Study: representativity, cancer incidence and mortality in participants and non-participants. Eur J Cancer Prev 2001;10(6):489–99. [PubMed: 11916347]
15. Heath AC, Howells W, Kirk KM, Madden PA, Bucholz KK, Nelson EC, et al. Predictors of non-response to a questionnaire survey of a volunteer twin panel: findings from the Australian 1989 twin cohort. Twin Res 2001;4(2):73–80. [PubMed: 11665339]
16. de Backer G, Thys G, de Craene I, Verhasselt Y, de Henauw S. Coronary heart disease rates within a small urban area in Belgium. J Epidemiol Community Health 1994;48(4):344–7. [PubMed: 7964331]
17. Morrison C, Woodward M, Leslie W, Tunstall-Pedoe H. Effect of socioeconomic group on incidence of, management of, and survival after myocardial infarction and coronary death: analysis of community coronary event register. Bmj 1997;314(7080):541–6. [PubMed: 9055711]
18. Diez-Roux AVKC, Jacobs DR Jr, Haan M, Jackson SA, Nieto FJ, Paton CC, Schulz R. Area characteristics and individual-level socioeconomic position indicators in three population-based epidemiologic studies. Ann Epidemiol 2001;11(6):395–405. [PubMed: 11454499]
19. Krieger N. Overcoming the absence of socioeconomic data in medical records: validation and application of a census-based methodology. Am J Public Health 1992;82(5):703–10. [PubMed: 1566949]
20. Diez Roux AV, Chambless L, Merkin SS, Arnett D, Eigenbrodt M, Nieto FJ, et al. Socioeconomic disadvantage and change in blood pressure associated with aging. Circulation 2002;106(6):703–10. [PubMed: 12163431]
21. LeClere FB, Rogers RG, Peters K. Neighborhood social context and racial differences in women's heart disease mortality. J Health Soc Behav 1998;39(2):91–107. [PubMed: 9642901]
22. Franzini L, Spears W. Contributions of social context to inequalities in years of life lost to heart disease in Texas, USA. Soc Sci Med 2003;57(10):1847–61. [PubMed: 14499510]
23. Horne BD, Muhlestein JB, Lappe DL, Renlund DG, Bair TL, Bunch TJ, et al. Less affluent area of residence and lesser-insured status predict an increased risk of death or myocardial infarction after

angiographic diagnosis of coronary disease. Ann Epidemiol 2004;14(2):143–50. [PubMed: 15018888]

24. Krieger N, Waterman PD, Chen JT, Soobader MJ, Subramanian SV. Monitoring socioeconomic inequalities in sexually transmitted infections, tuberculosis, and violence: geocoding and choice of area-based socioeconomic measures--the public health disparities geocoding project (US). Public Health Rep 2003;118(3):240–60. [PubMed: 12766219]
25. Cagney KA, Browning CR. Exploring neighborhood-level variation in asthma and other respiratory diseases: the contribution of neighborhood social context. J Gen Intern Med 2004;19(3):229–36. [PubMed: 15009777]
26. Latkin CA, Curry AD. Stressful neighborhoods and depression: a prospective study of the impact of neighborhood disorder. J Health Soc Behav 2003;44(1):34–44. [PubMed: 12751309]
27. Wang HC, McGeady SJ, Yousef E. Patient, home residence, and neighborhood characteristics in pediatric emergency department visits for asthma. J Asthma 2007;44(2):95–8. [PubMed: 17454322]
28. Krieger N, Chen JT, Waterman PD, Soobader MJ, Subramanian SV, Carson R. Choosing area based socioeconomic measures to monitor social inequalities in low birth weight and childhood lead poisoning: The Public Health Disparities Geocoding Project (US). J Epidemiol Community Health 2003;57(3):186–99. [PubMed: 12594195]
29. Subramanian SVCJ, Rehkopf DH, Waterman PD, Krieger N. Am J Epidemiol 2006;164(9)Am J Epidemiol 2006 Nov 1;164(9):823–34. [PubMed: 16968866]Epub 2006 Sep 12
30. Rosamond WD, Chambless LE, Folsom AR, Cooper LS, Conwill DE, Clegg L, et al. Trends in the incidence of myocardial infarction and in mortality due to coronary heart disease, 1987 to 1994. N Engl J Med 1998;339(13):861–7. [PubMed: 9744969]
31. Rosamond WD, Folsom AR, Chambless LE, Wang CH. Coronary heart disease trends in four United States communities. The Atherosclerosis Risk in Communities (ARIC) study 1987–1996. Int J Epidemiol 2001;30 (Suppl 1):S17–22. [PubMed: 11759846]
32. White AD, Folsom AR, Chambless LE, Sharret AR, Yang K, Conwill D, et al. Community surveillance of coronary heart disease in the Atherosclerosis Risk in Communities (ARIC) Study: methods and initial two years' experience. J Clin Epidemiol 1996;49(2):223–33. [PubMed: 8606324]
33. Prineas, RJ.; Crow, RS.; Blackburn, HW. The Minnesota Code Manual of Electrocardiographic Findings: Standards and Procedures for Measurement and Classification. Boston: J. Wright; 1982.
34. Whitsel EA, Rose KM, Wood JL, Henley AC, Liao D, Heiss G. Accuracy and repeatability of commercial geocoding. Am J Epidemiol 2004;160(10):1023–9. [PubMed: 15522859]
35. Foraker RE, Rose KM, Patel MD, Suchindran CM, WHitsel EA, JLW. Comparing neighborhood measures of socioeconomic status (SES) used for studying disparities in myocardial infarction (MI) incidence: Atherosclerosis Community Surveillance. Am J Epdemiol 2008;167(11S1):390S.
36. Barakat K, Stevenson S, Wilkinson P, Suliman A, Ranjadayalan K, Timmis AD. Socioeconomic differentials in recurrent ischaemia and mortality after acute myocardial infarction. Heart 2001;85 (4):390–4. [PubMed: 11250961]
37. Barnett E, Armstrong DL, Casper ML. Evidence of increasing coronary heart disease mortality among black men of lower social class. Ann Epidemiol 1999;9(8):464–71. [PubMed: 10549879]
38. Wing S. Social inequalities in the decline of coronary mortality. Am J Public Health 1988;78(11): 1415–6. [PubMed: 3177716]
39. Wing S, Barnett E, Casper M, Tyroler HA. Geographic and socioeconomic variation in the onset of decline of coronary heart disease mortality in white women. Am J Public Health 1992;82(2):204–9. [PubMed: 1739148]
40. Wing S, Casper M, Riggan W, Hayes C, Tyroler HA. Socioenvironmental characteristics associated with the onset of decline of ischemic heart disease mortality in the United States. Am J Public Health 1988;78(8):923–6. [PubMed: 3389429]
41. McGovern PG, Jacobs DR Jr, Shahar E, Arnett DK, Folsom AR, Blackburn H, et al. Trends in acute coronary heart disease mortality, morbidity, and medical care from 1985 through 1997: the Minnesota heart survey. Circulation 2001;104(1):19–24. [PubMed: 11435332]
42. Roger VL, Jacobsen SJ, Weston SA, Goraya TY, Killian J, Reeder GS, et al. Trends in the incidence and survival of patients with hospitalized myocardial infarction, Olmsted County, Minnesota, 1979 to 1994. Ann Intern Med 2002;136(5):341–8. [PubMed: 11874305]

43. Philbin EF, McCullough PA, DiSalvo TG, Dec GW, Jenkins PL, Weaver WD. Socioeconomic status is an important determinant of the use of invasive procedures after acute myocardial infarction in New York State. Circulation 2000;102(19 Suppl 3):III107–15. [PubMed: 11082372]
44. Pilote L, Joseph L, Belisle P, Penrod J. Universal health insurance coverage does not eliminate inequities in access to cardiac procedures after acute myocardial infarction. Am Heart J 2003;146 (6):1030–7. [PubMed: 14660995]
45. Rosvall M, Chaix B, Lynch J, Lindstrom M, Merlo J. The association between socioeconomic position, use of revascularization procedures and five-year survival after recovery from acute myocardial infarction. BMC Public Health 2008;8:44. [PubMed: 18241335]
46. Lang T, Ducimetiere P, Arveiler D, Amouyel P, Ferrieres J, Ruidavets JB, et al. Is hospital care involved in inequalities in coronary heart disease mortality? Results from the French WHO-MONICA Project in men aged 30–64. J Epidemiol Community Health 1998;52(10):665–71. [PubMed: 10023467]
47. Salomaa V, Miettinen H, Niemela M, Ketonen M, Mahonen M, Immonen-Raiha P, et al. Relation of socioeconomic position to the case fatality, prognosis and treatment of myocardial infarction events; the FINMONICA MI Register Study. J Epidemiol Community Health 2001;55(7):475–82. [PubMed: 11413176]
48. Krieger N, Chen JT, Waterman PD, Soobader MJ, Subramanian SV, Carson R. Geocoding and monitoring of US socioeconomic inequalities in mortality and cancer incidence: does the choice of area-based measure and geographic level matter?: the Public Health Disparities Geocoding Project. Am J Epidemiol 2002;156(5):471–82. [PubMed: 12196317]
49. Foraker RE, Rose KM, Patel MD, Suchindran CM, WHitsel EA, Wood JL. Comparing neighborhood measures of socioeconomic status (SES) used for studying disparities in myocardial infarction (MI) incidence: Atherosclerosis Community Surveillance. Am J Epidemiol 2008;167(11S1):390S.
50. DNBavas-Walt, C.; Proctor, BD.; Mills, R. Census USBot. Current Population Reports, Consumer Income. Washington D.C: U.S. Government Printing Office; 2004. Income, Poverty, and Health Insurance Coverage in the United States: 2003.
51. Sorlie PD, Coady S, Lin C, Arias E. Factors associated with out-of-hospital coronary heart disease death: the national longitudinal mortality study. Ann Epidemiol 2004;14(7):447–52. [PubMed: 15301780]
52. Krieger N, Fee E. Social class: the missing link in U.S. health data. Int J Health Serv 1994;24(1):25–44. [PubMed: 8150566]
53. Pickett KE, Pearl M. Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review. J Epidemiol Community Health 2001;55(2):111–22. [PubMed: 11154250]
54. Robert SA. Neighborhood socioeconomic context and adult health. The mediating role of individual health behaviors and psychosocial factors. Ann N Y Acad Sci 1999;896:465–8. [PubMed: 10681952]
55. Yen IH, Kaplan GA. Neighborhood social environment and risk of death: multilevel evidence from the Alameda County Study. Am J Epidemiol 1999;149(10):898–907. [PubMed: 10342798]
56. Moore LV, Diez Roux AV. Associations of neighborhood characteristics with the location and type of food stores. Am J Public Health 2006;96(2):325–31. [PubMed: 16380567]
57. Duncan SC, Duncan TE, Strycker LA, Chaumeton NR. Neighborhood physical activity opportunity: a multilevel contextual model. Res Q Exerc Sport 2002;73(4):457–63. [PubMed: 12495248]
58. Frank LD, Saelens BE, Powell KE, Chapman JE. Stepping towards causation: do built environments or neighborhood and travel preferences explain physical activity, driving, and obesity? Soc Sci Med 2007;65(9):1898–914. [PubMed: 17644231]
59. Powell LM, Slater S, Chaloupka FJ, Harper D. Availability of physical activity-related facilities and neighborhood demographic and socioeconomic characteristics: a national study. Am J Public Health 2006;96(9):1676–80. [PubMed: 16873753]
60. Cutrona CE, Wallace G, Wesner KA. Neighborhood Characteristics and Depression: An Examination of Stress Processes. Curr Dir Psychol Sci 2006;15(4):188–192. [PubMed: 18185846]
61. Ewart CK, Suchday S. Discovering how urban poverty and violence affect health: development and validation of a Neighborhood Stress Index. Health Psychol 2002;21(3):254–62. [PubMed: 12027031]

62. Steptoe A, Feldman PJ. Neighborhood problems as sources of chronic stress: development of a measure of neighborhood problems, and associations with socioeconomic status and health. Ann Behav Med 2001;23(3):177–85. [PubMed: 11495218]

63. Datta GD, Subramanian SV, Colditz GA, Kawachi I, Palmer JR, Rosenberg L. Individual, neighborhood, and state-level predictors of smoking among US Black women: a multilevel analysis. Soc Sci Med 2006;63(4):1034–44. [PubMed: 16650514]

64. Miles R. Neighborhood disorder and smoking: findings of a European urban survey. Soc Sci Med 2006;63(9):2464–75. [PubMed: 16904800]

65. Ross CE. Walking, exercising, and smoking: does neighborhood matter? Soc Sci Med 2000;51(2): 265–74. [PubMed: 10832573]

66. King WC, Belle SH, Brach JS, Simkin-Silverman LR, Soska T, Kriska AM. Objective measures of neighborhood environment and physical activity in older women. Am J Prev Med 2005;28(5):461–9. [PubMed: 15894150]

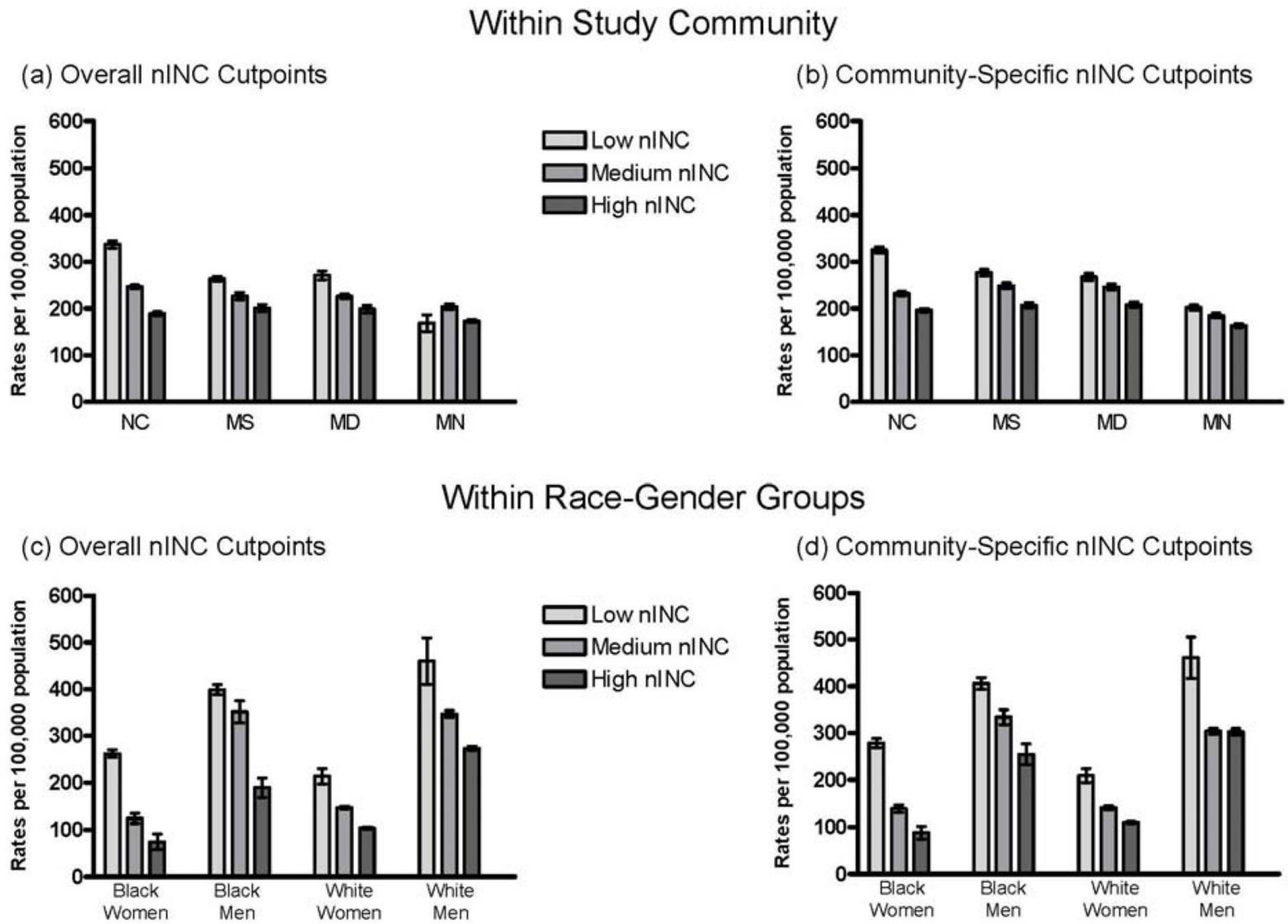

Figure 1.

Figure 1(a–d). Age-adjusted Incidence of Myocardial Infarction by Tertile of Median Household Income, by Study Community and Race-Gender Groups: ARIC Surveillance Communities (1993–2002)

NIH-PA Author Manuscript

NIH-PA Author Manuscript

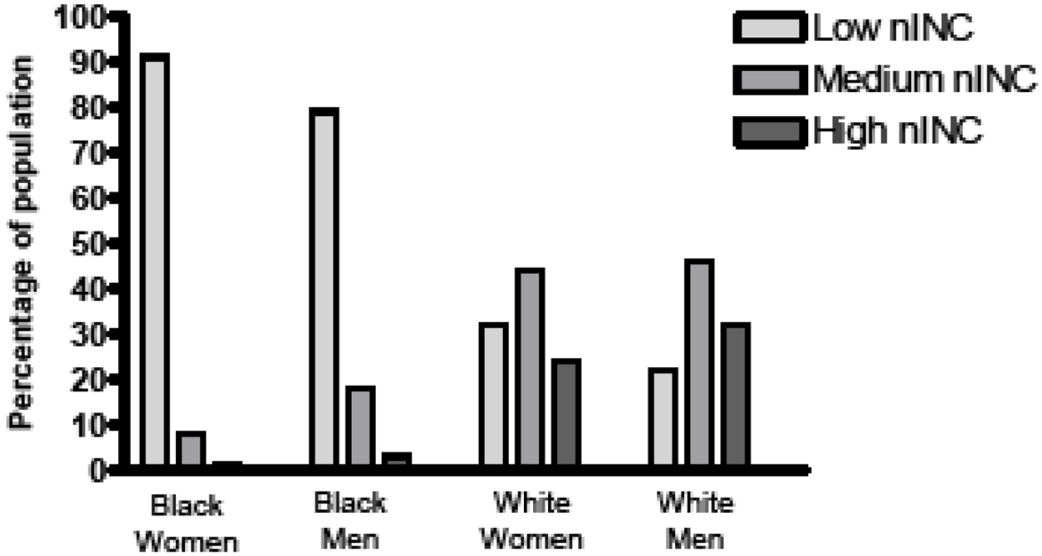

Figure 2.
Distribution of Incident MI Cases by Tertile of Median Household Income, ARIC Surveillance Communities (1993 – 2002)

Table 1

Characteristics of Eligible Population by ARIC Study Community, 2000 Census

	Washington Co. Maryland	Minneapolis Minnesota	Jackson (city) Mississippi	Forsyth Co. North Carolina
Race-gender composition	N	N	N	N
Black Women	1,330	4,694	26,976	18,181
Black Men	1,220	4,380	21,545	15,175
White Women	29,048	48,329	8,491	53,272
White Men	27,033	45,168	7,137	47,887
Total population[1]	58,631	102,571	64,149	134,515
Number of census tracts	31	55	43	75
Average persons per census tract[1]	1,891	1,865	1,492	1,794
Median Household Income[2]	$44,307	$54,508	$25,480	$41,579
Community-specific tertiles				
High nINC	>$46,761	>$60,383	>$30,727	>$48560
Medium nINC	$34,018–46,761	$50,032–60,383	$20,521–30,727	$33,750–48,560
Low nInc	<$34,018	<$50,032	<$20,521	<$33,750

[1]Limited to White and Black persons ages 35 to 74 years.

[2]Calculated by averaging median household incomes for each census tract in the area.

Table 2

Myocardial Infarction Incident Rate Ratios (IRR) and 95% Confidence Intervals (95% CI) for Race-Gender Groups by Census Tract Median Household Income (nINC), ARIC Community Surveillance, 1993–2002

	Overall Cutpoints		Community-Specific Cutpoints	
	N of MI Events[1]	**IRR (95% CI)**	**N of MI Events[1]**	**IRR (95% CI)**
Black Women				
Low nINC	645	2.14 (1.69, 2.58)	454	2.05 (1.69, 2.42)
Medium nINC	135	1.31 (0.81, 1.81)	278	1.40 (1.01, 1.79)
High nINC[2]	37	-	85	-
Black Men				
Low nINC	756	1.63 (1.20, 2.06)	490	1.41 (1.05, 1.76)
Medium nINC	211	1.42 (0.95, 1.88)	413	1.43 (1.04, 1.82)
High nINC[2]	65	-	129	-
White Women				
Low nINC	412	1.79 (1.58, 2.00)	523	1.74 (1.57, 1.91)
Medium nINC	988	1.37 (1.21, 1.53)	837	1.23 (1.07, 1.39)
High nINC[2]	752	-	792	-
White Men				
Low nINC	595	1.24 (1.07, 1.41)	759	1.22 (1.09, 1.35)
Medium nINC	1833	1.20 (1.07, 1.33)	1569	1.11 (0.98, 1.24)
High nINC[2]	1706	-	1806	-

[1] Weighted to reflect sampling fractions used in ARIC Surveillance study.

[2] Referent.